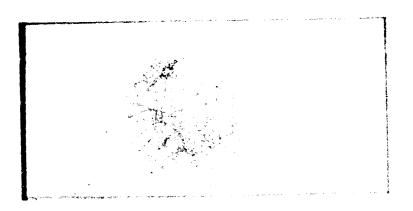
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THE UNIVERSITY OF KANSAS CENTER FOR RESEARCH, INC.

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Interim Report
for
A PROGRAM TO EVALUATE A CONTROL SYSTEM
BASED ON FEEDBACK OF AERODYNAMIC
PRESSURE DIFFERENTIALS

KU-FRL-490-1

Part I

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August 1981

ABSTRACT

This report describes work done under a program to evaluate the use of pressure differentials in a flight control system.

The first part of the program consists of a study to determine the pressure profile around the test surface. This study was performed using two techniques:

- 1) Windtunnel Data (Actual)
- 2) NASA/Langley Single Element Airfoil Computer Program (Theoretical).

The system designed to evaluate the concept of using pressure differentials is composed of a sensor drive and power amplifiers, actuator, position potentiometer, and a control surface.

The second part of this program consists of determining the characteristics (both desired and actual) of the system and each individual component. This report, however, terminates with the desired characteristics of the system as a whole. The actual frequency response of the system could not be obtained due to the use of an inappropriate sensor.

This report describes the flight control system developed, the testing procedures and data reduction methods used, and theoretical frequency response analysis.

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LIST OF SYMBOLS AND ACRONYMS

Symbol	Definition	Dimension
C _p	Pressure coefficient	
q	Dynamic pressure	lbs, ft ⁻²
Œ	Angle of attack	deg
θ	Euler pitch angle	deg
δ _E	Elevator angle	deg
^ω n sp	Undamped natural frequency of the short period mode	Hz
ωn . P	Undamped natural frequency of the dutch roll mode	
ΔΡ	Change in pressure between lower and upper surface	lbs, ft^{-2}

Acronyms

DAS	Data Acquisition System
AFCS	Automatic Flight Control System
SEAP	Single Element Airfoil Program
SSSA	Separate Surface Stability Augmentation

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1. INTRODUCTION

1.1 PURPOSE

The purpose of this study is to provide information leading to determining the feasibility of using a differential pressure feedback signal in an airplane's flight control system.

1.2 BACKGROUND

In nearly all airplanes equipped with automatic flight controls (AFC), the control surfaces are positioned via a feedback loop with a feedback gain proportional to control surface position. Since in many instances control surface position is linearly related to the differential pressure created by a control surface deflection, this type of feedback works well.

However, in many systems, it is found necessary to schedule the feedback gain as a function of flight attitude, Mach number, dynamic pressure, or a combination thereof. (At this point in time, Mach number is not included.)

Since the purpose of any control motion is to create a certain pressure differential, it is logical to consider a system whereby control surface motion is signalled by a gain directly proportional to the pressure differential. The differential itself would then have to be sensed by a suitable pressure sensor.

This method of control surface signalling may simplify control law requirements. It may also allow for the direct control of sirplane attitude relative to the total velocity vector of an

airplane. This is because such attitudes are themselves proportional to pressure differentials across lifting surfaces (Reference 1).

1.3 METHODOLOGY

This study was performed using the following three phases:

- 1) Pressure profile study
- 2) Sensor calibration
- Frequency response and transfer function determination.

The pressure profile study is used to determine the range and characteristics of the test surface. The sensor calibration phase is needed to obtain the sensor's physical characteristics. (The actual work of this study terminated at This phase.) A theoretical frequency response analysis has been conducted; but at the time of this report, the physical testing of this phase has not begun, due to the results of Phase II.

2. SYSTEM DESCRIPTION

2.1 OVERALL SYSTEM THEORY

The flight control system which was designed to test the use of a differential pressure sensor is illustrated in Figure 2.1. The block diagram is a pitch attitude hold system with the differential pressure feedback for the $\delta_{\mbox{\footnotesize ECOMM}}$. loop is illustrated in Figure 2.2.

2.2 CUMPONENT BREAKDOWN

The components used in the testing are listed in the flow diagram of Figure 2.2 and can be found in the appropriate drawings according to Table 2.1.

Table 2.1 Guide to Delta P Drawings

Drawing No.(s)	Component
DP-0105	Sensor
DP-0204	Sensor Circuit Schematic
DP-0204	Sensor Wiring Diagram and Layout
DP-0301	Signal Conditioner (Control Box)
DP-0204	Signal Conditioner Schematic
DP-0204	Signal Conditioner Wiring Diagram and Layout
DP-0301	Drive Amplifier
DP-0301 DP-0203	Power Amplifier
DP-0203	Power Amplifier Schematic
DP-0101	Actuator (Assembly View)
DP-0101	Position Potentiometer (Assembly View)
DP-0101	Delta P Test Surface (Assembly View)

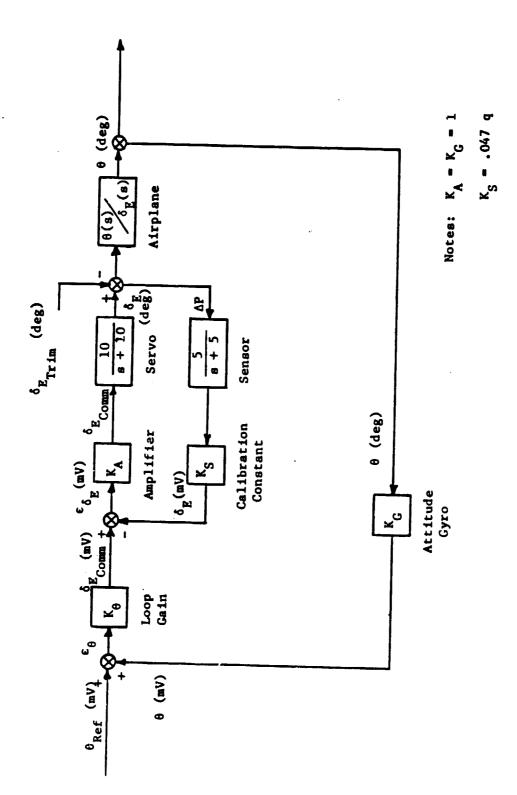


Figure 2.1 System Block Diagram

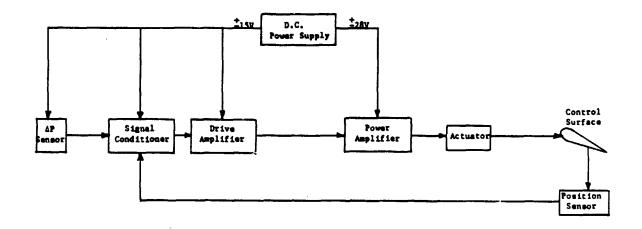


Figure 2.2 System Flow Diagram

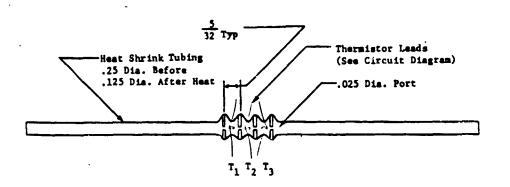


Figure 2.3 Differential Pressure Sensor

2.2.1 SENSOR

The sensor used in this study was designed by Jim Black,

NASA DFRC Engineer. The sensor uses three thermistors to measure

the differential pressure between the two ports. Figure 2.3 illustrates

the sensor's components. The circuit diagram for the sensor is found

in Figure 2.4.

The sensor, designed to be used in a wing-leveler autopilot system, operates by keeping the middle thermistor at a constant temperature. As the air flows past the front thermistor (a flow due to differential pressure), it is cooled. After passing the middle thermistor, the air is heated, thus causing the rear thermistor to be at a different temperature. This temperature difference results in a voltage difference within the sensor circuit. This difference, again, is the result of a pressure differential.

2.2.2 SIGNAL CONDITIONER

The signal conditioner in the flow diagram performs the following tasks:

- 1) Reads the differential pressure signal from the sensor-circuit combination
- 2) Monitors the position of the control surface.

 The signal conditioner uses the signal from the position potentioneter to prevent a hardover condition.

The circuit diagram for the signal conditioner is given in Figure 2.5. The signal conditioner (designed by Dr. D. G. Daugherty,

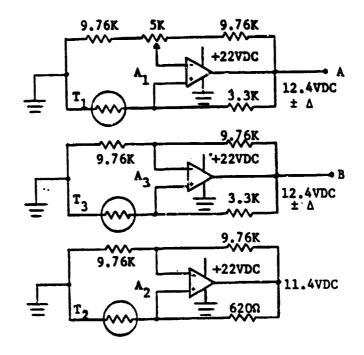


Figure 2.4 Sensor Circuit Schematic

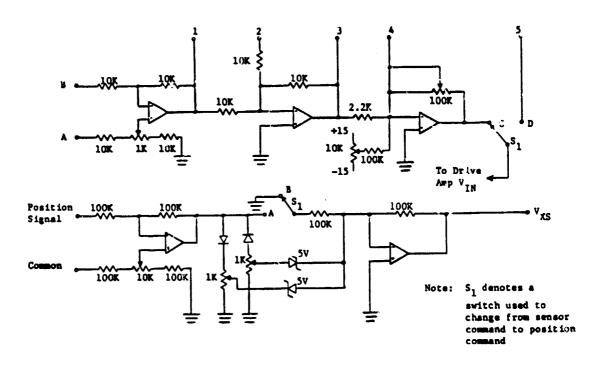


Figure 2.5 Signal Conditioner Schematic

KU Electrical Engineering Professor) was also designed to aid the frequency response testing of Phase III. To do this, test points and input terminals were included; their functions are listed in Table 2.2.

Table 2.2 Signal Conditioner Test Points and Input Terminals

Circuit Point No.	Symbol	Function
1	+P (OUT)	Differential Pressure Output Signal
2	-P _c (IN)	Frequency Response Signal Input
3	$P_c-P = \epsilon$	Error Signal
4	Comp.	Compensating Circuit Signal (if Required)
5	P.C.	Position Command Signal- Sensor can be bypassed and surface controlled using position potentiometer (LVDT)

2.2.3 DRIVE AMPLIFIER

The drive amplifier used in this study is from the NASA M99 separate Surface Stability Augmentation (SSSA) Project. The schematic of the drive amplifier may be found in Figure 2.6.

The drive amplifier uses standard op-amp methods for developing opposite phase drive signals required by the power amplifier. Discrete transistors connected as complementary emitter-followers provide the necessary drive current for the power amplifier inputs. Small (56 Ω) resistors are included in the collector circuits of

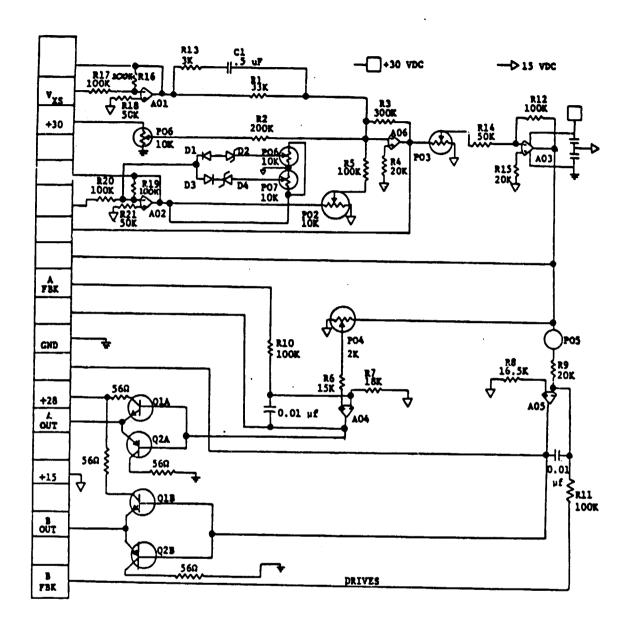


Figure 2.6 Drive Amplifier Schematic (Reference 2)

these emitter-followers as protection against mishaps during circuit testing. In normal circuit operation their function is inconsequential (Reference 2).

The drive amplifier receives the $V_{\mbox{\footnotesize{IN}}}$ signal from the signal conditioner, while also monitoring the position of the surface through the $V_{\mbox{\footnotesize{XS}}}$ terminal. The output then goes to the power amplifier.

2.2.4 POWER AMPLIFIER

The power amplifier used in this study is also from the SSSA project. The schematic of the power amplifier is given in Figure 2.7.

The power amplifier is a Class-B push-pull bridge configuration. This configuration was used in order to attain actuator voltages approaching ±28 volts (56 volts, peak-to-peak). Diodes are included for protecting the power transistors against inductive spikes from the actuator (Reference 2).

The power amplifier receives four (4) signals from the drive amplifier:

- 1) A FDBK
- 2) A IN
- 3) B FDBK
- 4) B IN

The A and B FDBK signals are transmitted directly to the actuator.

It is these signals which drive the actuator. The A and B IN signals originate at the drive amplifier. The A and B IN signals are connected to the drive amplifiers A and B OUT terminals, respectively.

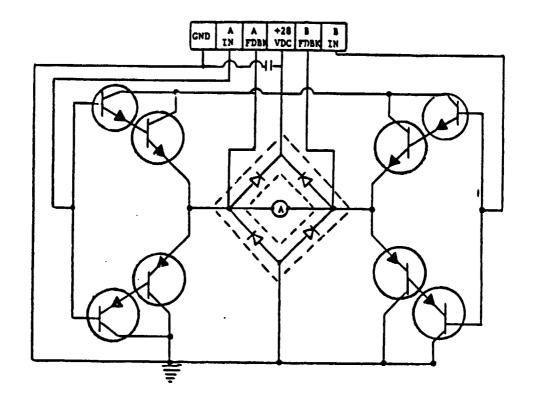


Figure 2.7 Power Amplifier Schematic

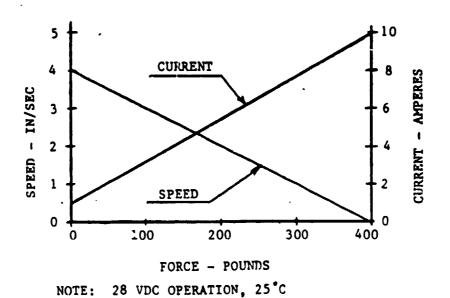


Figure 2.8 Solactor Actuator Properties

NOTE:

2.2.5 ACTUATOR

The actuator used in this study is the McDonnell Douglas "Solactor," Model 6023 A, also used in the SSSA project. The properties of the actuator are given in Figure 2.8.

2.2.6 POSITION POTENTIOMETER

The position potentiometer (L.V.D.T.) used in this study has the following characteristics:

- 1) Type: III
- 2) Resistance: $2K \Omega \pm 10\%$
- 3) Range: 3" linear: 1%

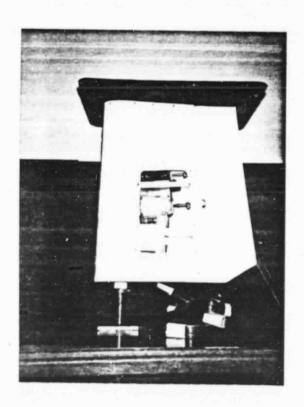
2.2.7 SURFACE AND MOUNTING HARDWARE

The test surface used in this study is the Beech, Model 60 (DUKE), elevator-trim tab assembly. The surface was obtained through the Aerospace Engineering Department at the University of Kansas.

The surface and mounting hardware are illustrated in Figures 2.9 and 2.10. Also included in these figures are the actuator and L.V.D.T. Table 2.3 gives a listing of the detailed drawings of the surface and mounting hardware which are available through the Flight Research Lab, at the University of Kansas Center for Research, Inc.



Figure 2.9 Test Surface and Mounting Hardware



OF POOR QUALITY

Figure 2.10 Test Surface (Assembly View)

Table 2.3 Delta P Surface and Hardware Drawings

Drawing No.	Item
DP-0101	Test Surface (Assembly View)
DP-0102	Potentiometer Clevis
DP-0102	Actuator Clevis
DP-0102	Windtunnel Mount
PP-0102	Mounting Rib
DP-0103	Aft Actuator Mount
DP-0103	Fore Actuator Mount
DP-0104	Endplate Mount
DP-0104	Endplate

3. PHASE I: PRESSURE PROFILE STUDY

3.1 PURPOSE

3.1.1 BASELINE DATA ON PRESSURE DISTRIBUTION

Because of the uniqueness of the airfoil used, a pressure profile study is necessary to obtain baseline data on the pressure distribution at specific angles of attack and flap deflections.

The data obtained during this study are used against the theoretical analysis of Section 6.1. If the pressure distribution can be predicted, then a windtunnel pressure profile study can be eliminated.

3.1.2 SENSOR LOCATION

The major objective of the pressure profile study is to determine the location of the differential pressure sensor.

The control system illustrated in Figure 2.2 is designed primarily for flap deflection sensitivity; however, provisions have been made in the signal conditioner control box for angle of attack sensitivity. The selection can be made through a switch mounted on the control box.

The locations of the sensors are determined using the results of the data reduction. These results are best summarized using the graphs found in the data presentation of this report. These graphs show how the change in the pressure coefficient, $\Delta C_p = C_p$ and $C_p = C_p$ changes with angle of attack and flap deflections for Pupper locations.

The criteria for selection are as follows:

- Sensor No. 1: a) Sensitivity to angle of attack
 - b) Least sensitivity to flap deflection
 - c) Consistent linesrity
- Sensor No. 2: a) Least sensitivity to angle of attack
 - b) Sensitivity to flap deflection
 - c) Consistent linearity

With sensors at these two locations, both angle of attack and flap deflection can be sensed separately and accurately within the range of linear aerodynamics.

3.1.3 SENSOR RANGE

Results from the pressure profile study are also used to determine the range of pressure required to be sensed by the sensor. It is this characteristic which the sensor does not have.

3.2 FACILITIES AND HARDWARE

3.2.1 WINDTUNNEL

All testing of the surface was performed at the University of Kansas Aerospace Engineering Department's 3' x 4' subsonic windtunnel. Facilities include a 60 tube manometer, 26 of which were used for this study. The manometer may be seen in Figure 3.1. Figure 3.2 views the test surface before a run.

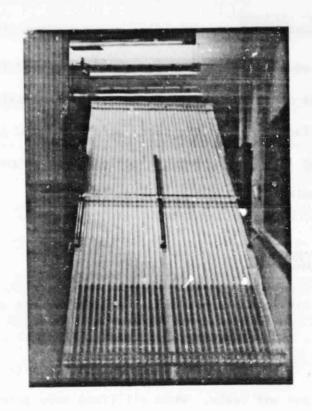


Figure 3.1 Manometer Board

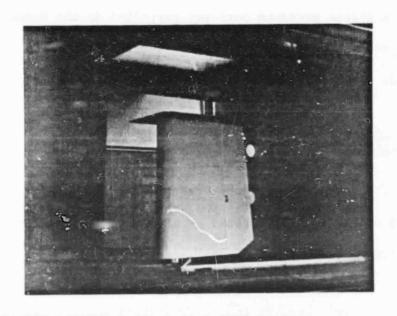


Figure 3.2 Test Surface in Wind Tunnel

3.2.2 TEST SURFACE

Provisions were made on the test surface of Figure 3.2 to measure the pressure profile at 13 different locations, on each side of the surface. All static ports were connected to the manometer board using 1/16" I.D. pressure tubing. All connections were made airtight using a polyurethane spray lacquer.

3.3 TEST SET-UP

The test set-up consisted of installing the surface in the windtunnel, and connecting the pressure lines to the appropriate connectors on the manometer board. Each pressure line was tested for blockages and leaks. When all lines were determined to be clear and airtight, the testing began. The manometer board was tilted at a 30° angle to match the inclination of the tunnel pitot-static manometer; this simplifies the data reduction.

A static pressure port was installed in the tunnel test section.

The port was used for a reference static pressure on the manometer board. Corrections due to position are outlined in Subsection 3.5.1.

3.4 PROCEDURES

The procedures for the pressure profile testing followed the items of Table 3.1. A total of nine runs were performed. Each run consisted of the following steps:

- 1) Setting flap at desired deflection
- 2) Setting tunnel at desired dynamic pressure

- 3) Obtaining equilibrium condition in manometer board tubes
- 4) Setting surface at minimum angle of attack (-8°)
- 5) Reading manometer board pressure tubes
- 6) Repeating Steps (3) and (5) for angles of attack
 -8° to +8° by increments of 2.

Table 3.1 Pressure Profile Run Log

Run No.	CL.	δ _F (deg)
1	a Sweep	- 20
2		- 15
3		- 10
4		- 5
5		o
6		+ 5
7		+ 10
. 8		+ 15
9	†	+ 20

^{*}a_{SWEEP}: -8,-6,-4,-2,0,+2,+4,+6,+8 (degrees)

Note: All testing was performed for a tunnel dynamic pressure of 25.6 psf.

3.5 DATA PROCESSING

3.5.1 DATA CORRECTIONS

The raw data obtained from the Phase I testing includes:

- Static pressure at the 26 locations along the test surface (P_a)
- 2) Static pressure in the test section (P_)
- 3) Dynamic pressure at the test section (q)

These values, in centimeters of alcohol, are read from the manometer board, inclined to 30°. Before the data can be reduced, two corrections must be made. First, the dynamic pressure must also be corrected for tunnel blockage. The procedure of Pope (Reference 3) is followed.

Second, the test section static pressure port (see Figure 3.3), being located forward of the test surface leading edge, reads slightly high due to the increase in dynamic pressure over the surface from tunnel blockage. The incompressible Bernoulli equation is used to calculate the true reference static pressure from the change in dynamic pressure due to blockage.

The corrections are detailed in Part II of this report, which contains all the data obtained from the pressure profile study.

Included in Part II are sample calculations, computer program

listings, and presentations (tabular and graphical) of the data.

3.5.2 DATA REDUCTION

Since the inclination of the manometer board (used to measure the test surface's static pressure) is identical to the dynamic pressure manometer tube, the coefficient of pressure is calculated directly from:

$$c_{p} = \frac{P_{s} - P_{\infty}}{q}.$$
 (3.1)

where the pressures have been corrected as per Subsection 3.5.1.

Since differential pressure is the quantity to be investigated,
the difference between the lower and upper coefficients is calculated.

However, the lower and upper pressure tap locations are not the
same. Therefore, the lower surface pressure coefficients are
linearly interpolated to the upper surface tap locations.

It is desired to find the chordwise locations that satisfy the criteria specified in Subsection 3.1.2. Toward this end, the change in pressure coefficient, C - C , is plotted pupper against flap deflection and angle of attack for each of the 13 chordwise tap locations. (These graphs are located in Appendix A and in Part II.) This facilitates inspection and interpretation of the data. A numerical regression of the data is performed to quantify the slopes of these graphs. This augments the interpretation of the figures and is used in the theoretical analysis of Section 6.2.

3.6 RESULTS AND DISCUSSION

Based on the figures of Appendix A, tap number (13) (x/c = .766) has the best combination of linear sensitivity to flap deflection, and insensitivity to angle of attack. One pressure sensor, located here, can sense flap position with little error to angle of attack. The location of tap number (1) is best for angle of attack sensitivity, but is not used for the purpose of this study.

The required range of the sensor is best put in terms of pressure coefficient:

$$-1.2 \le \Delta C_p \le 1.2$$
 (3.2)

This is the nondimensional differential pressure occurring at the largest angle of attack and flap deflection tested. At a dynamic pressure of q = 25 psf, the required range is:

$$-30 \le \Delta P \le +30 \text{ psf}$$
 (3.3)

If this study is to be repeated, it is recommended that a more common airfoil, with a known, experimental pressure distribution be used. For example, a NACA 0012 would be a good choice because of its wide use in horizontal tails.

4. PHASE II: SENSOR CALIBRATION

4.1 PURPOSE

The sensor calibration process is performed to determine the relationship between the differential pressure acting on the sensor, and its output. From this process the drive amplifier's gain value is determined.

4.2 FACILITIES AND HARDWARE

4.2.1 FACILITIES

The calibration tests were performed using the windtunnel facilities previously mentioned in Section 3.2. Also included in the facilities is the Hewlett Packard (HP) 2012 Data Acquisition System (DAS), HP9825 micro-minicomputer, and the HP9872 X-Y plotter, all shown in Figures 4.1 and 4.2. A schematic of the entire data acquisition system is illustrated in Figure 4.3.

4.2.2 HARDWARE

The hardware and components used for the calibration tests included:

- 1) Differential pressure sensor
- 2) Sensor calibration mount
- 3) Signal conditioner

The calibration mount is shown in Figure 4.4. The mount provides a pitot-static pressure differential across the sensor which is

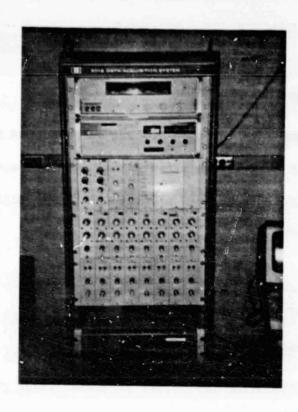


Figure 4.1 2012 Data Acquisition System

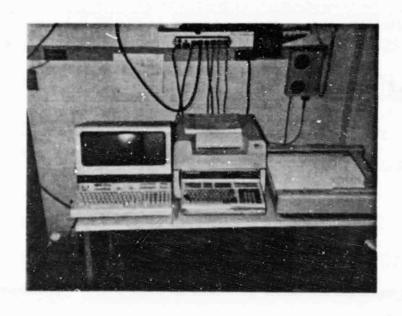


Figure 4.2 HP9825 A Computer and 9872 Plotter

Test Section T P Force-Balance HP-9825 A Tape 9872 Magnetic Paper CRT Voltmeter Scanner Computer and Peripherals Expander Controls Inter-Gage

HP-2012 Data Acquisition System

Figure 4.3 Data Acquisition System Schematic

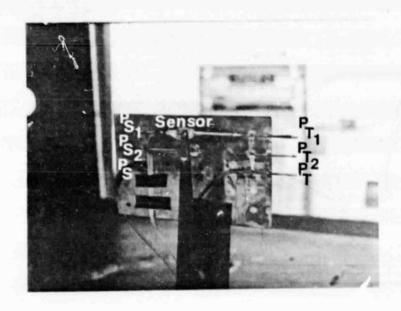


Figure 4.4 Pressure Sensor Calibration Mount

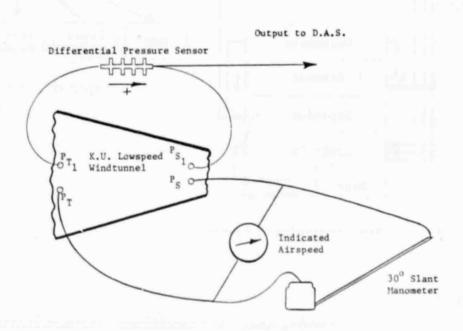


Figure 4.5 Calibration Schematic

calibrated against the tunnel manometer. The apparatus utilizes a "u" shaped windtunnel mount to secure it in the tunnel.

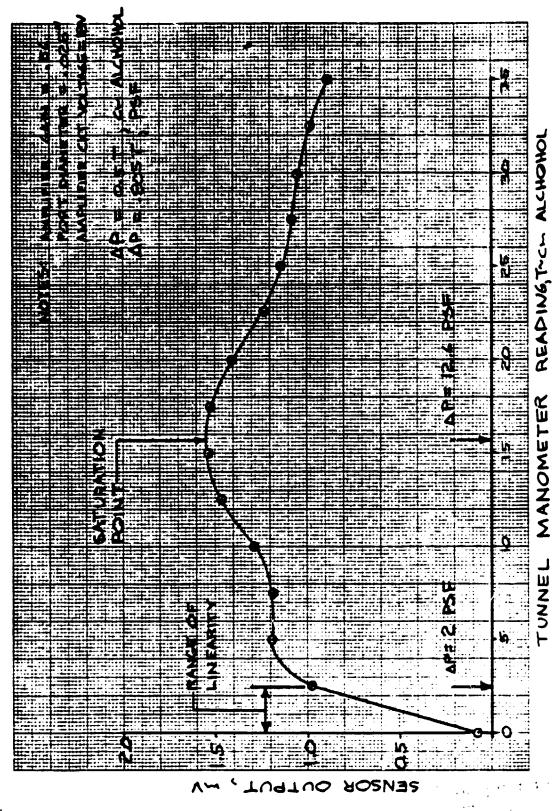
4.3 TEST SET-UP

The schematic of Figure 4.5 illustrates the uses of the components for the calibration process. The set-up consists of securing the sensor on the calibration mount and checking the side-slip angle (\$\beta\$) of the plate so the flow becomes just attached.

Channels 12 and 13 of the DAS are then zeroed. This is done using the 5K Ω potentiometer of Figure 2.4. In effect, this is causing the output of the fore and aft thermistors to equal, negatively. Once initialized, the calibration process can begin.

4.4 PROCEDURES

The calibration procedures follow the computer listing of Appendix B on Page 81. Once initialized, the computer asks for the tunnel dynamic pressure, which is the differential pressure of the sensor. As the desired tunnel dynamic pressure is attained, the DAS takes 10 sampled values and obtains the average. This average is then used in the output and for plotting purposes. Table 4.1 gives the output of a typical calibration run. The output is then plotted in Figure 4.6. As indicated in the output, the tunnel dynamic pressure range is from 0 to 35 cm of alcohol, or 0 to 27.2 psf.



CALC	Marko	18	AEVIGED	DATE	Figure 4.6 Sensor Calibration		
CHECK					Curve		
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Table 4.1 Calibration Run Data

Manometer Dynamic Pressure (cm. of alcohol)	Transducer Output (mVolts)		
0	- 0.080		
2.5	- 0.982		
5.0	- 1.185		
7.5	- 1.183		
10.0	- 1.290		
12.5	- 1.464		
15.0	- 1.538		
17.5	- 1.525		
20.0	- 1.410		
22.5	- 1.225		
25.0	- 1.140		
27.5	- 1.083		
30.0	- 1.049		
32.5	- 0.982		
35.0	- 0.889		

4.5 RESULTS AND DISCUSSION

The results of the calibration tests indicate that for this type of application, the sensor is not adequate due to shortcomings in two areas:

- 1) Sensor range
- 2) Dynamic response.

It was found that the sensor produced a linear output only up to approximately 2 psf. In addition, the sensor became completely saturated at values up to 13 psf. As outlined in Section 3.6, the required linear range of the sensor is ±30 psf.

A pressure sensor can usually be mathematically modelled by a pure lag. Although specific dynamic response tests were not performed, it was observed that approximately 10 seconds was

required for the sensor output to return to zero after a pressure differential was removed. This type of response is unacceptable in a feedback control system.

4.6 MODIFICATIONS AND SUBSEQUENT RESULTS

Various methods were tried to obtain different sensor characteristics. The following methods were suggested by Jim Black, designer of the sensor:

- 1) Change sensor port diameter
- 2) Change amplifier gain.

4.6.1 SENSOR PORT DIAMETER

The sensor port diameter was changed from the original diameter of .025" to a diameter of .0135". This was done by plugging both ports on the calibration mount with epoxy. The epoxy was ther drilled out to a .0135" diameter (#80 drill).

The calibration process was then repeated. It was found that while the sensor range was slightly increased, the dynamic response characteristics were degraded.

4.6.2 AMPLIFIER GAIN

The amplifier (sensor) was altered by changing the resistance of the input resistor to the amplifier of Figure 2.4. The amplifier gain was changed to values of .01, .10, and .50. Again, the saturation point remained unchanged.

4.6.3 AMPLIFIER VOLTAGE

The sensor circuit of Figure 2.4 defines the input voltage to the amplifier as +22 volts d.c. The amplifier voltage used in the testing was set at 15 volts d.c. To and if any difference would result, the voltage was increased to 18 volts d.c. (the limit voltage for the LM 324N OP AMP). This tended to increase the saturation point, but still not to the required value. The linear range appeared to be unchanged.

4.6.4 MIDDLE THERMISTOR

A sensor thermistor profile was conducted to determine how the voltage, current, and resistance of each thermistor in the sensor was changing as the pressure differential increased. It was concluded that the middle thermistor was not able to increase its power output after a relatively low pressure was applied to the sensor. Four (4) different thermistors replaced the middle thermistor to check this theory. Using values of 5K, 10K, 50K, and 100K Ω , the power output of the middle thermistor was increased. The results were encouraging but still saturated out before maximum estimated pressure differential occurred.

4.7 CONCLUSIONS AND RECOMMENDATIONS

The sensor is not suitable for the purpose of this study.

There are two types of pressure sensors available today that meet the needs of the project.

Conventional diaphragm pressure sensors have the range, accuracy, and dynamic response required but are relatively expensive.

A Piezoresistive sensor offers the same qualities for a reasonable cost. A brief literature search is recommended before final selection is made.

5. PHASE III: FREQUENCY RESPONSE

Phase III of this study is designed to determine the transfer function for the system, actuator, and sensor. The circuit can be either assumed to be a pure gain, or determined analytically. Once these transfer functions are known, a closed loop analysis of a typical feedback control system can be performed, and the stability determined. A theoretical analysis of a typical control system is included in Section 6.2.

Phase III is composed of Parts A, B, and C. The objective of Part A is to obtain standard lift, drag, and pitching moment coefficients and their variations with α and δ_F . The run schedule for Part A is given in Table 5.1.

Table 5.1 Part A Run Schedule

Run No.	Œ.	δ _F (degrees)	q (psf)
1 2 3 4 5 6 7 8	① 	- 20 - 15 - 10 - 5 0 + 5 + 10 + 15 + 20	25

Note: 1 $\alpha = -8, -6, -4, -2, 0, +2, +4, +6, +8$ (degrees)

Part B of Phase III is designed to obtain preliminary data on system performance at various angles of attack and initial flap positions. (Several of the runs may be deleted if the initial

indications are promising.) This is accomplished by applying a step input to the pressure sensor via the signal conditioner control box. The run schedule for Part B is given in Table 5.2.

Table 5.2 Part B Run Schedule

Run No.	a (deg)	ΔP COMMAND*	δ _F (deg)	q (psf)
1 2 3 4 5 6 7 8 9	- 8 - 8 - 4 - 4 - 0 0 + 4 + 4 + 8 + 8	2	- 10 0 - 10 0 - 10 0 - 10 0 - 10	25

Note: 2
$$\Delta C_p = 0.1, 0.3, 0.5, 1.0$$
 or $\Delta P = 2.5, 7.5, 12.5, 25$ psf at $q = 25$ psf

The data obtained will be presented as illustrated in Figure 5.1.

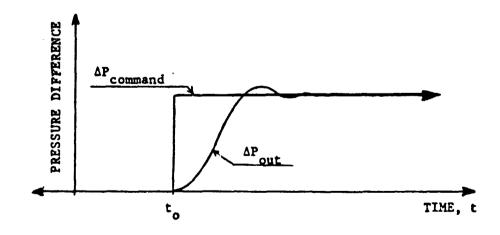


Figure 5.1 Response to a Step Input

Part C will be used to determine the necessary frequency response characteristics of the system. A total of 18 windtunnel runs will be used to obtain the data, each containing the following:

INPUTS $\delta_{F_{IN}}(t) = |\delta_{F_{IN}}|\cos\omega t \qquad \delta_{F_{OUT}}(t) = |\delta_{F_{OUT}}|\cos(\omega t + \phi_1)$ $\Delta P_{OUT}(t) = |\Delta P_{OUT}|\cos(\omega t + \phi_2)$ $\Delta P_{IN}(t) = |\Delta P_{IN}|\cos\omega t \qquad \delta_{F_{OUT}}(t) = |\delta_{F_{OUT}}|\cos(\omega t + \phi_3)$ $\Delta P_{OUT}(t) = |\Delta P_{OUT}|\cos(\omega t + \phi_4)$

The reader should note the following:

- 1) $\delta_{\mathbf{F}}$ inputs directly into the actuator.
- 2) AP inputs into the control circuit.
- 3) Frequency range: .01 < ω < 1000 rad/sec.

Tables 5.3 (a) and (b) give the run schedules for this part of the frequency response testing. The sinusoidal inputs to the actuator and sensor will be accomplished by connecting a function generator to the appropriate inputs on the signal conditioner.

A two-channel strip chart recorder will be used to monitor the outputs of the sensor and L.V.D.T.

The data obtained during this phase of the study would be presented in the form of a standard bode plot. It will be from these plots that a transfer function will be derived. These transfer functions will then be tested against those used in the theoretical analysis of Section 6.2.

Table 5.3(a) Frequency Response Test Runs - Position

Run No.	a (deg)	⁶ F _{IN}	AP IN	q (psf)
1 2 3 - 4 5 6 7 8	- 8° - 6 - 4 - 2 0 + 2 + 4 + 6 + 8	3	-	25

Table 5.3(b) Frequency Response Test Runs - Pressure

Run No.	a (deg)	⁶ F _{IN}	ΔP _{IN}	q (psf)
1 2 3 4 5 6 7 8	- 8 - 6 - 4 - 2 0 + 2 + 4 + 6 + 8	-	2	25

Note:
$$2 |\Delta P_{IN}| = 2.5,7.5,12.5,25 \text{ psf at } q = 25 \text{ psf}$$

$$3 |\delta_{F_{IN}}| = 5,10,15,20 \text{ degrees}$$

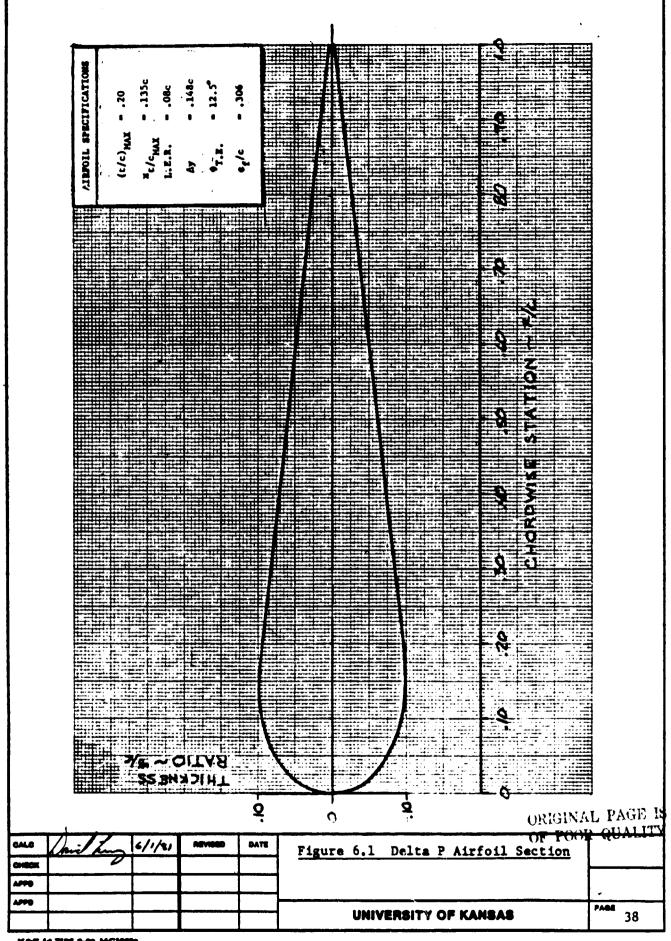
THEORETICAL ANALYSIS

6.1 THEORETICAL PRESSURE DISTRIBUTION

The windtunnel test described in Chapter 3 required significant amounts of time, manpower, and hardware development. It is desirable to find a way to bypass the need for this test. If a commonly used airfoil with the necessary testing already performed (e.g., NACA 4 and 5 digit airfoils) is chosen, then the published results can be used instead of repeating the test. However, the test surface employed for this study incorporated a unique airfoil (see Figure 6.1) with an unknown pressure distribution. Therefore, to avoid windtunnel testing, numerical methods must be used. The method used for this study was the NASA/Langley Single Element Airfoil Program (SEAP), which was stored on the University of Kansas Honeywell 66/60.

The program requires, as input, the airfoil coordinates listed in Table 6.1. Mach number and Reynolds number inputs are the same as in the Phase I testing. Included in the output is a listing of the pressure coefficients at chordwise stations along the airfoil (see Appendix B for sample output).

A total of 16 cases were input to the program—four angles of attack (α = 0, 3, 6, 9°) and four flap deflections (δ_F = 0, 5, 10, 15°). It is assumed that symmetry holds with respect to angle of attack and flap deflections. Flap deflections are input to the program by altering the airfoil coordinates aft of the hingeline (see Figure 6.2 and Table 6.2). Due to difficulties with software, results were not obtained for the case of α = 9°, δ_F = 0°.



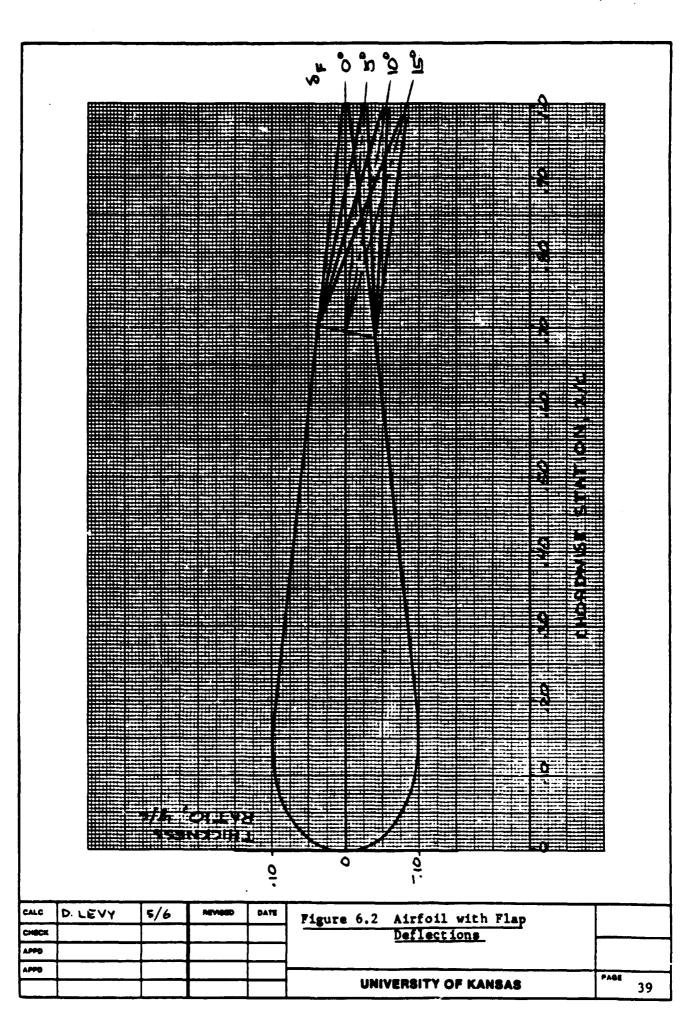


Table 6.1 Delta P Airfoil Coordinates - Zero Flap Deflection

XU (=XL)	ZU (= -EL)	XU (-XL)	ZU (= -ZL)
0	0	.325	.080
.00625	.032	.350	.077
.0125	.043	.375	.074
.01875	.052	.400	.071
.0250	.057	.425	.06825
.03125	.064	.450	.0655
. 0375	.069	.475	.06275
.04375	.073	.500	.060
.0500	.077	.525	.05725
.05625	.081	.550	.0545
,0625	.083	.575	.05175
.06875	.085	.600	.049
.0750	.087	.625	.04625
.08125	.090	.630	.0435
.0875	.092	.675	.04075
.09375	.093	.700	.038
.100	.094	.725	.035
.1125	.0965	.750	.032
.125	.098	.775	.029
.1375	.100	.800	.026
.150	.099	.825	.02325
.1625	.0985	.858	.0205
.175	.097	.875	.01775
.1875	.096	.900	.015
.200	.095	.925	.01225
.225	.092	.950	.0095
.250	.089	.975	.00675
.275	.086	1,000	.004
.300	.083		1

Table 6.2 Delta P Airfoil Coordinates - Flap
Deflection = 5, 10, 15 (degrees)

Substitute into Table 6.1 for $.70 \le XU \le 1.00$

XU (=XL)	6,7	- 5°	6 ₇ ·	10°	6 _F = 15° *	
AU (-AL)	.,	ZL	ZU	ŽĹ	zu	ZL
.700	.038	040	.038	041	.037	043
.725	.032	039	.0305	0425	-	-
.750	.027	038	.023	044	.017	050
.775	.022	037	.0155	~.0455	-	-
.800	.017	036	.005	04.7	003	057
.825	.012	0355	.0005	0485	-	-
.850	.007	035	007	050	023	064
.875	.002	034	0145	051	-	-
.900	003	033	022	052	043	071
,925	008	032	0295	0535	-	-
.950	013	031	637	055	063	078
.975	018	030	0445	0565	-	-
1.000	023	029	052	058	083	083

For the δ_p = 15° case, it was necessary to input a slightly fewer number of coordinates. Since the aft portion of the surface is essentially flat, this is considered to make little, if any, difference.

The C_p values generated are at distributed points (chosen by the computer) along the airfoil. Consequently, for comparison with the windtunnel data, the pressure coefficients are interpolated to the 13 chordwise locations of the test surface. Then the same data reduction process outlined in Subsection 3.5.2 is performed on the data. The results are tabulated and plotted in Appendix C.

From Figures C.1 through C.26 it is seen that the general sensitivity trends follow those of the windtunnel data. However, contrary to the experimental data, the pressure differential, at all locations, is sensitive to flap deflection. In addition, the results are somewhat nonlinear—especially at the five degree flap deflection case. The maximum C_p predicted by the SEAP at x/c = .766 agrees reasonably well with the experimental data, but this is not the case at the forward tap locations.

There are a few explanations for the discrepancies between the experimental and theoretical data. First, the large thickness ratio (t/c) and extreme forward location of the maximum t/c might not lend itself to accurate analysis by the SEAP. Second, since the program is not specifically designed to handle flap deflections, the method of doing so could lead to errors. Finally, the program utilizes a two-dimensional analysis technique, while the windtunnel test is three dimensional.

while the results of the theoretical analysis do not correlate exactly with the experimental data, they are promising enough to prompt further study. Analysis of other airfoils, perhaps with another computer program more suited to the specific needs of the project, is recommended before discounting the theoretical approach.

6.2 CLOSED LOOP DYNAMIC STABILITY ANALYSIS

A study has been performed to see what the closed loop performance of a system is (or should be) that incorporates differential pressure command as opposed to elevator position command. In analyzing the system, the block diagram of Figure 6.3 is used. The system illustrated is a pitch attitude hold loop which uses pressure as the feedback quantity in the $\delta_{\rm E}$ inner loop. As a control COMMAND a conventional pitch attitude hold system which incorporates elevator position command (of Figure 6.4) was also analyzed.

For simplification, the amplifier of the inner loop has been assumed to be a pure gain, equal to unity:

$$K_{AMP} = 1 \tag{6.1}$$

The elevator servo is assumed to be a first order lag:

$$\frac{\delta_{\mathbf{E}}(\mathbf{s})}{\delta_{\mathbf{E}_{OUT}}(\mathbf{s})} = \frac{10}{\mathbf{s} + 10}$$
 (6.2)

The break frequency of 10 rad/sec is representative of a reasonably fast, general aviation actuator.

The sensor calibration constant, or position command gain, is a function of dynamic pressure and is obtained from the numerical regression of Chapter 10, Part II, of this report:

$$\frac{\partial \Delta C}{\partial \delta_F} = .047 \tag{6.3}$$

or:

$$\frac{\partial \Delta P}{\partial \delta_{\mathbf{F}}} = K_{\text{SENSOR}} = .047q \qquad (6.4)$$

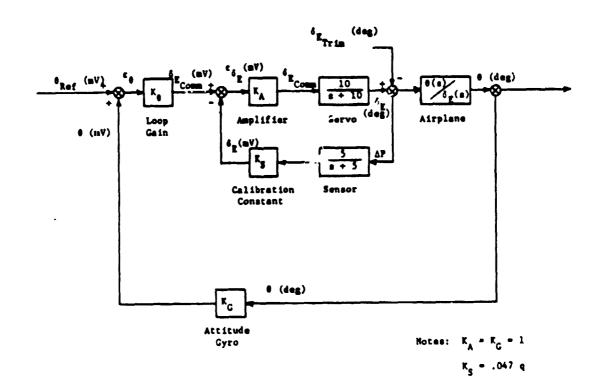


Figure 6.3 System Block Diagram (Pressure Command)

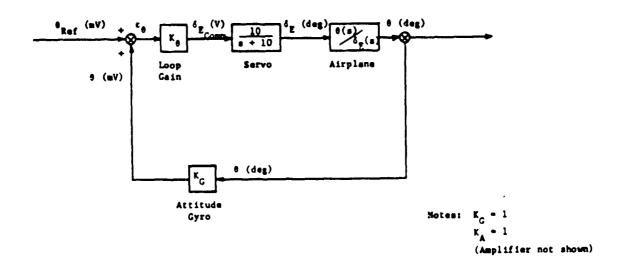


Figure 6.4 System Block Diagram (Position Command)

The aerodynamic lag and the sensor lag are combined into one first order transfer function:

$$\frac{\delta_{E \text{ IN}}}{\Delta P_{\text{OUT}}(s)} = \frac{a}{s+a} = \frac{5}{s+5}$$
 (6.5)

The break frequency of 5 rad/sec has been assumed as "reasonable."

The experimental determination of this lag is one of the major purposes of the Phase III windtunnel test.

The airplane $\frac{\theta(s)}{\delta_E(s)}$ transfer function is derived using data obtained from Appendix B of Reference 4 for a typical general aviation airplane. To investigate the effect of dynamic pressure on system performage, high and low values were used:

Case 1:
$$q = 8.47 \text{ psf } (K_{q} = .40)$$

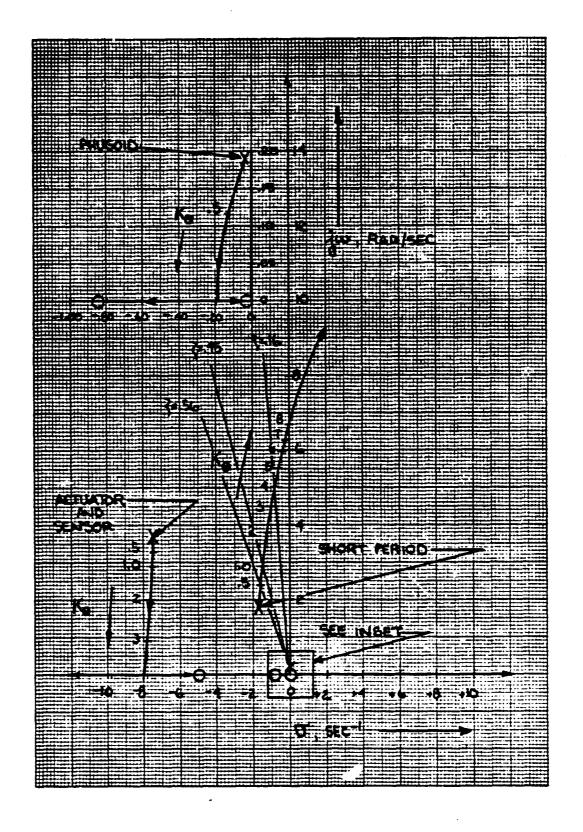
Case 2:
$$q = 76.28 \text{ psf } (K_g = 3.59)$$

Using Reference 5 in conjunction with the University of Kansas Aerospace Engineering Departmen's HP9825A micro-minicomputer, the airplane $\frac{\theta(s)}{\delta_E(s)}$ transfer function was derived for each case; and the root loci of Figures 6.5 through 6.8 were generated. The computer output used to construct the root loci is located in Appendix D. Notice that with the inner loop pressure command, the sensor and actuator combine to form an oscillatory pair. In fact, Figure 6.6 shows that it is these poles which go unstable at high dynamic pressure.

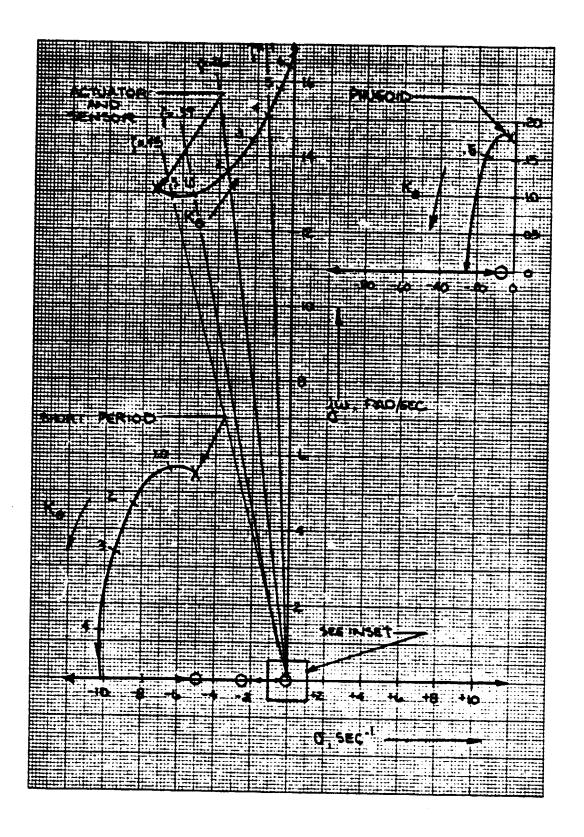
It can be seen from the figures that a loop gain equal to

$$K_A = 1.0$$
 (6.6)

The aerodynamic lag represents the lag between a change in $\delta_{\mbox{\it E}}$ and the resulting pressure change at the sensor.

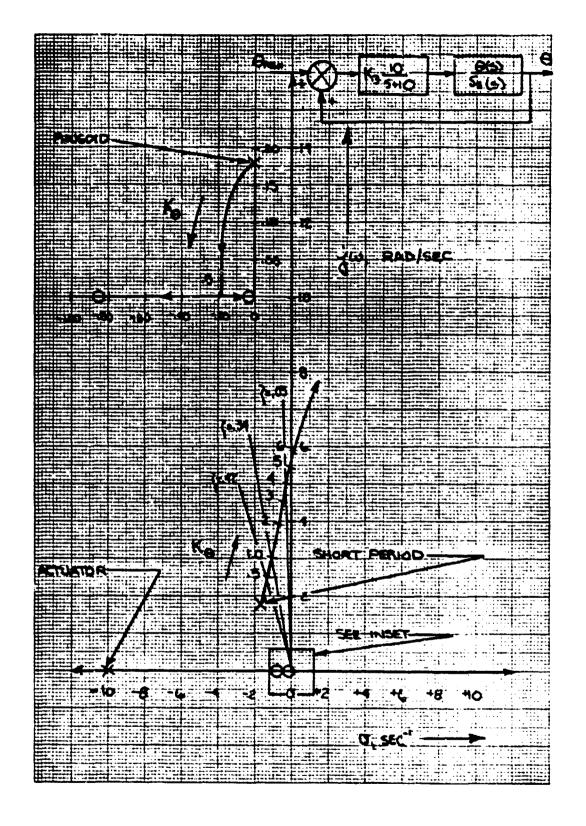


CMC	R. Hopgar	REVIOED	DATE	Figure 6.5 Pitch Attitude Hold for		
CHECK			P/5(8)	Airplane A (App. C, Ref 4)		
APPO				with Pressure Sensor		
APPO				(q= 8.5 psf)	PAGE	<i>1.</i> E
				University of Kansas		45

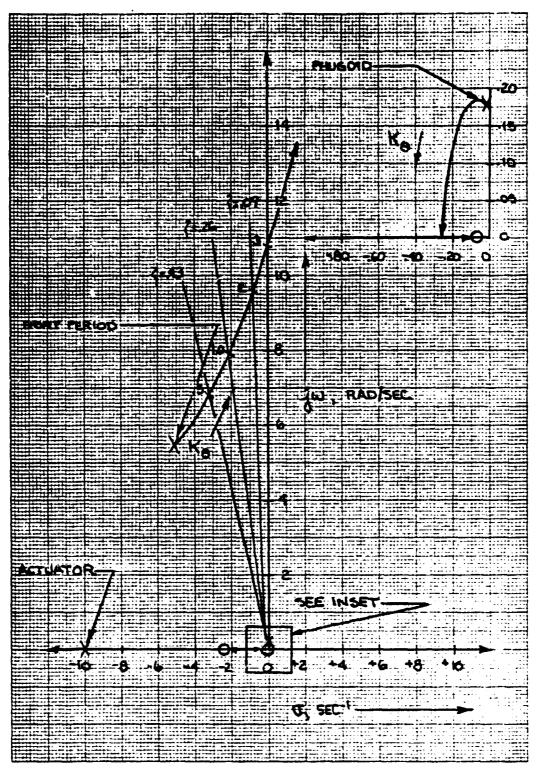


CALC	R. HRABAH	MEYHSED	DATE	Figure 6.6 Pitch Attitude Hold for		
CHICK		4/0/01		Airplane A (App. C, Ref	4)	
APPO				with Pressure Sensor	_	
APPD				(q= 76.3 psf)		
				UNIVERSITY OF KANSAS	PAGE	46

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CALC	R. Horask	REVISED	DATE	Figure 6.7	Pitch Attitude Hold for		
CHECK			8/5/81		Airplane A (App. C, Ref 4)		
APPO					(q= 8.5 psf)		'
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CALC	R. HABAK	REVISED	DATE	Figure 6.8 Pitch Attitude Hold for	
CHECK			0/5/81	Airplane A (App. C, Ref 4)	
APPD				(q= 76.3 psf)	
APPD					PAGE
				UNIVERSITY OF KANSAS	48

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yields reasonable damping ratios and natural frequencies for the pressure sensor pitch attitude hold system. It is also observed that in the system with the pressure sensor, the gain margin remains relatively constant with dynamic pressure as compared to the conventional system. It appears that gain scheduling with dynamic pressure can be avoided without a compensator or inner loop pitch damping.

Again it should be noted that the sensor properties have not been determined. The frequency response data obtained during Phase III will yield the necessary information for a more detailed study. This analysis is merely a preliminary investigation of the closed loop characteristics of the pressure feedback system.

7. CONCLUSIONS AND RECOMMENDATIONS

The sensor used in this study does not have the qualities required to determine the feasibility of differential pressure feedback in a flight control system. Of available sensors, the piezoresistive has the characteristics most suited for this type of application.

Once this concept has been proven feasible, a follow-up program is recommended which will include the use of a more conventional airfoil. Within this program, both theoretical and experimental pressure distributions should be investigated.

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 Submitted to NASA Dryden Flight Research Center, July 1980;
 University of Kansas Center for Research, Inc., Flight Research Lab.
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APPENDIX A

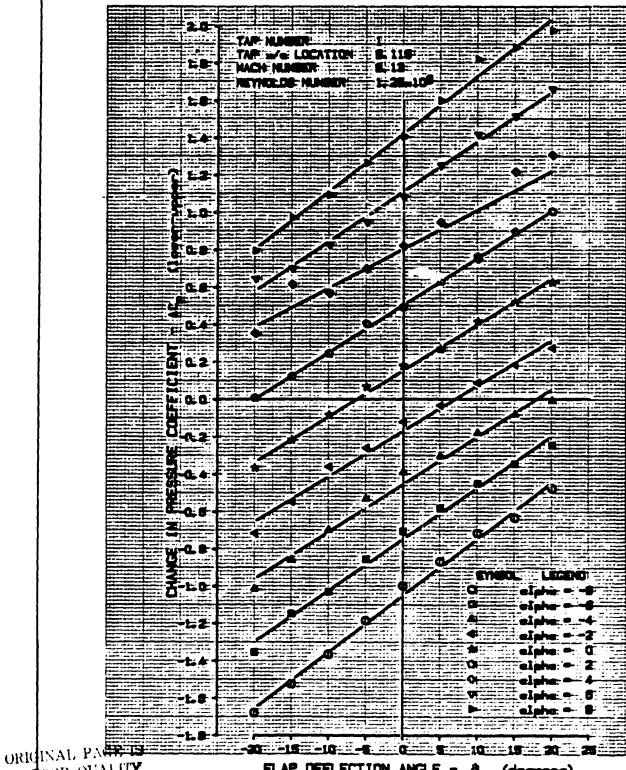
PRESSURE PROFILE SENSITIVITY PLOTS

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A.1 FLAP DEFLECTION

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NOTE: LOWER SUMPACE CO INTERPOLATED TO UPPER SUMPACE TAP LOCATION

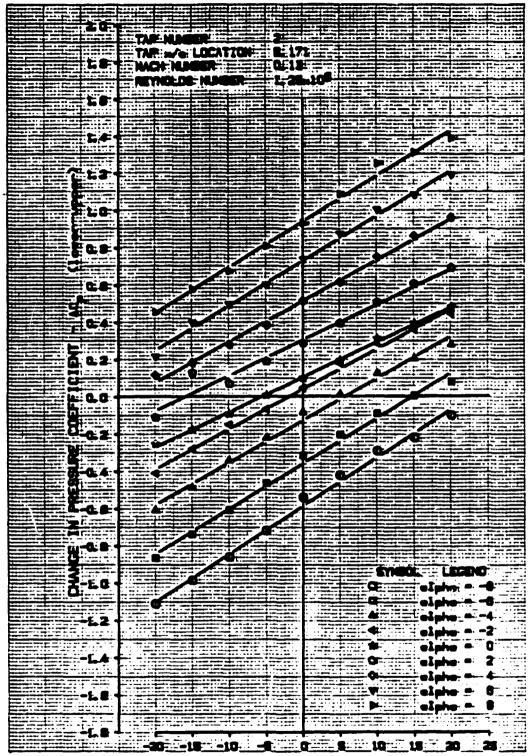


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FLAP DEFLECTION ANGLE - $\theta_{\rm p}$ (degrees)

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APPO					- FLAP DEFLECTION SENSITIVITY	
APPO					95(104) 4 7 4 7	
					UNIVERSITY OF KANSAS	PAGE 58

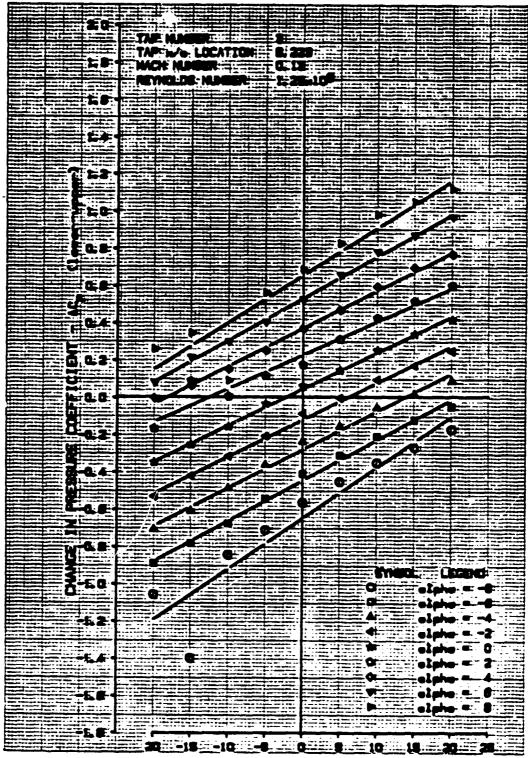
NOTE: LOWER SUFFACE C. INTERPOLATED TO UPPER SUFFACE TAP LOCATION



FLAP DEFLECTION ANGLE - & (degrees)

CALC	P. FINN	5-61	NEVISED	DATE	FIGURE A. 1. 2 EXPERIMENTAL CHANGE IN	DATE
СНЕСК	D. LEVY	5/25/84			PRESSURE COEFFICIENTS - FLAP DEFLECTION	20-5-61
APPO					SENSITIVITY	
APPO						PAGE
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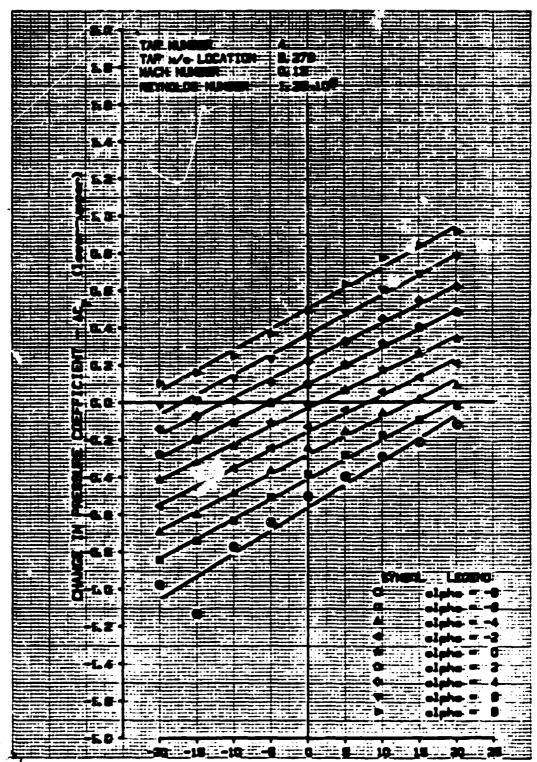
NOTE: LOWER SUPPLIES CO INTERPOLATED TO UPPER SUPPLIES TAP LOCATION



FLAP DEFLECTION ANGLE - 8 (degrees)

CALC	P. FINN	5-01	AEVISED	DATE	FIGURE A. 1. 3	EXPERIMENTAL CHANGE IN	DATE
CHECK	D. LEVY	5/28/4/			•	PRESSURE COEFFICIENTS	20 -5-0 1
APPO						- FLAP DEFLECTION SENSITIVITY	
APPO							74QE
					UNIVE	RSITY OF KANSAS	60

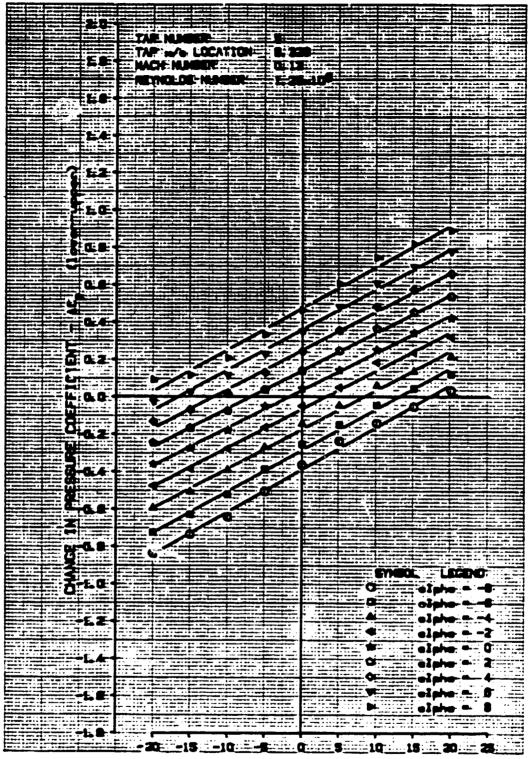
NOTE: LOWER SUMPACE CO INTERPOLATED TO UPPER SUMPACE TAP LOCATION



FLAP DEFLECTION ANGLE - 8, (degrees)

CALG	P. FINN	5-61	AEVISED	DATE	FIGURE A. 1. 4	EXPERIMENTAL CHANGE IN	DATE
CHECK	DILEVY	5/75/4				PRESSURE COEFFICIENTS	20-5-01
APPO						- FLAP DEFLECTION SENSITIVITY	
APPO							PAGE
					UNIVE	RSITY OF KANSAS	61

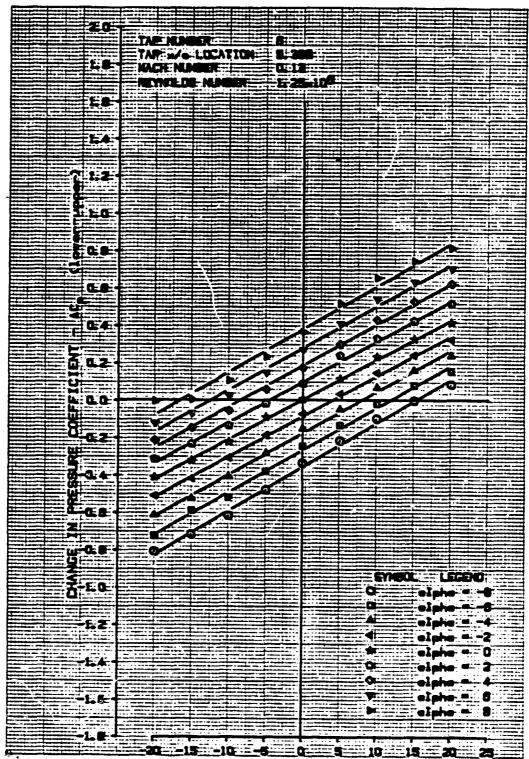
NOTE: LOWER SUPPACE CO INTERPOLATED TO UPPER PRIVACE TAP LOCATION



FLAP DEFLECTION ANGLE - 8, (degrees)

CALC	P. FINN	5-01	REVISED	DATE	FIGURE A. 1. 5 EXPERIMENTAL CHANGE IN	DATE
CHECK	D. LEUY	5/25/3			PRESSURE COEFFICIENTS	20-5-81
APP0	1				- FLAP DEFLECTION	
APPO					SENSITIVITY	-
					UNIVERSITY OF KANSAS	PAGE 62

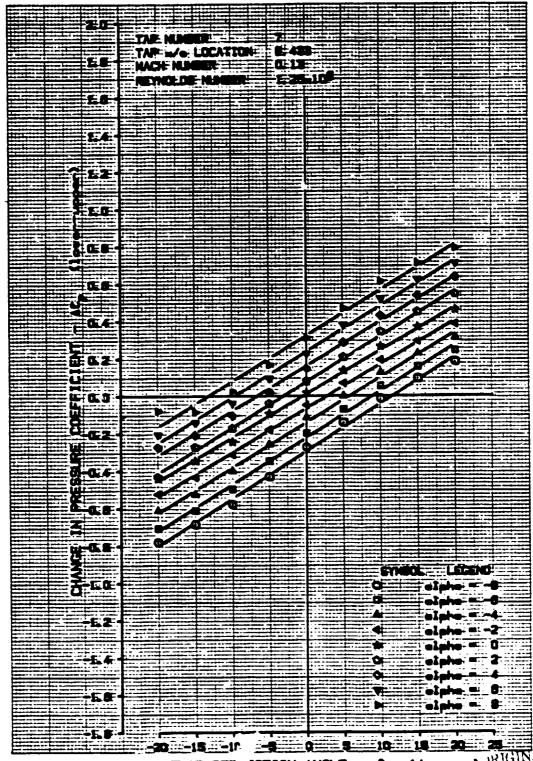
NOTE: LOWER SUMFACE CP INTERPOLATED TO UPPER SUMFACE TAP LOCATION



FLAP DEFLECTION ANGLE - 8, (degrees)

CALC	P. FINN	5-01	REVISED	DATE	FIGURE A. 1. 6 EXPERIMENTAL CHANGE IN	DATE
CHECK	D. LEVY	5/25/5			PRESSURE COEFFICIENTS	20 -5- 81
APPO					- FLAP DEFLECTION	
APPO			,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,		<u> SENSITIVITY</u>	
					UNIVERSITY OF KANSAS	PAGE 63

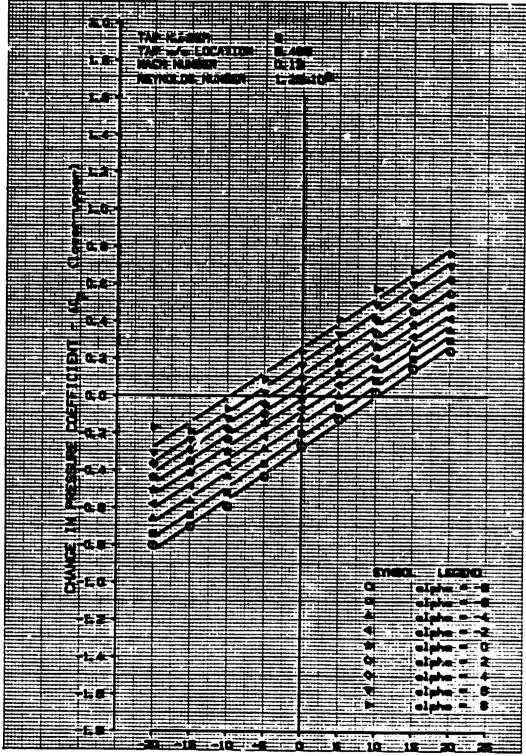
NOTE: LOWER SURFACE CP INTERPOLATED TO UPPER SURFACE TAP LOCATION



FLAP DEFLECTION ANGLE - 8, (degrees) JRIGINAL PAGE IS OF POOR QUALITY

CALC	P. FINN	5-61	REVISED	DATE	FIGURE A. 1. 7	EXPERIMENTAL CHANGE IN	DATE 20-5-01
СНЕСХ	DILEVY	5/25/8/				PRESSURE COEFFICIENTS - FLAP DEFLECTION	20-3-61
APPO						SENSITIVITY	
APPO				ļ	IINIVE	RSITY OF KANSAS	PAGE 64
					UNIVER	ISH TOP RANSAS	04

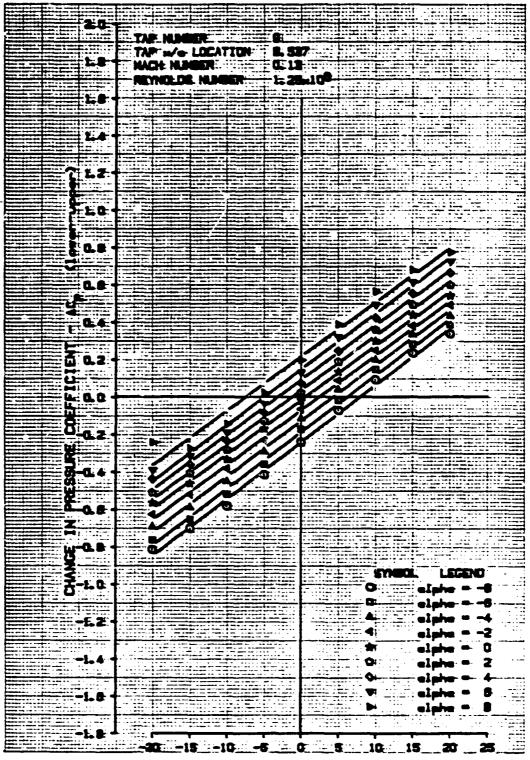
NOTE: LOWER SUIFACE CO INTERPOLATED TO UPPER SUIFACE TAP LOCATION



FLAP DEFLECTION ANGLE - 8 (degrees)

CALC	P. FINN	5-01	REVISED	DATE	FIGURE A. 1. 8 EXPERIMENTAL CHANGE IN	DATE
CHECK	D.LEVY	5/25/8/	· · · · · · · · · · · · · · · · · · ·		PRESSURE COEFFICIENTS	21-5-01
APPO					- FLAP DEFLECTION	
APPO					SENSITIVITY	
					UNIVERSITY OF KANSAS	PAGE 65

NOTE: LOWER SURFACE CO INTERPOLATED TO UPPER SURFACE TAP LOCATION



FLAP DEFLECTION ANGLE - 8, (degrees)

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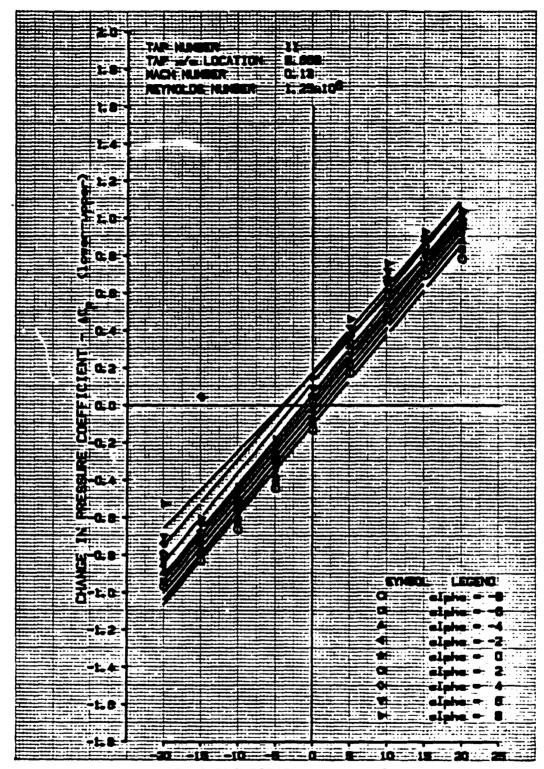
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CALC	P. FINN	5-61	AEVISED	DATE	FIGURE A. 1. 9	EXPERIMENTAL CHANGE IN	DATE
CHECK	D. LEVY	5/25/5/				PRESSURE COEFFICIENTS	21-5-01
APPO						- FLAP DEFLECTION SENSITIVITY	
APPO							PAGE
					UNIVE	RSITY OF KANSAS	66

NOTE: LOWER SURFACE C. INTERPOLATED TO UPPER SURFAC. TAP LOCATION

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CALC	P. FINN	5-81	REVISED	DATE	FIGURE A. 1. 10 EXPERIMENTAL CHANGE IN	DATE
CHECK	DILEVY	5/25/81			PRESSURE COEFFICIENTS - FLAP DEFLECTION	21-5-01
APPO			_		SENSITIVITY	
APPO					UNIVERSITY OF KANSAS	PAGE 67

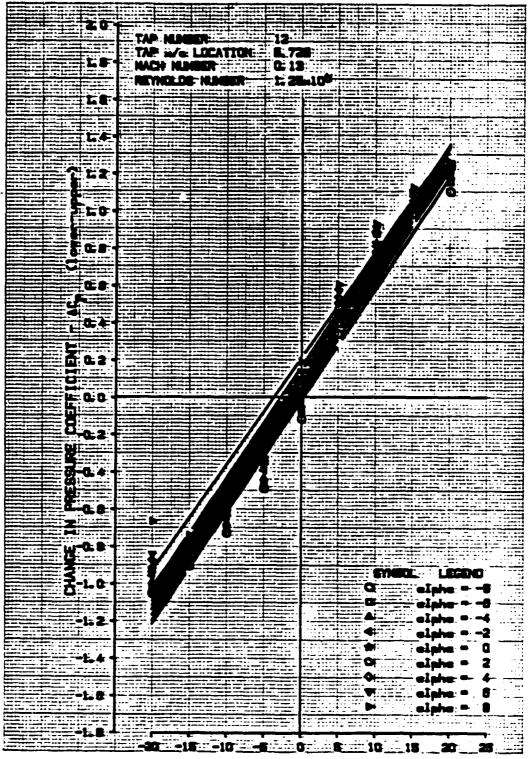
NOTE: LOWER SUNFACE CO INTERPOLATED TO UPPER SUNFACE TAP LOCATION



FLAP DEFLECTION ANGLE - 8, (degrees)

CALC	P. FINN	5-01	REVISED	DATE	FIGURE A. 1. 11	EXPERIMENTAL CHANGE IN	DATE
CHECK	D-LEVY	5/25/4				PRESSURE COEFFICIENTS	21-5-01
APPO						- FLAP DEFLECTION SENSITIVITY	
APPO							PAGE
					UNIVE	RSITY OF KANSAS	68

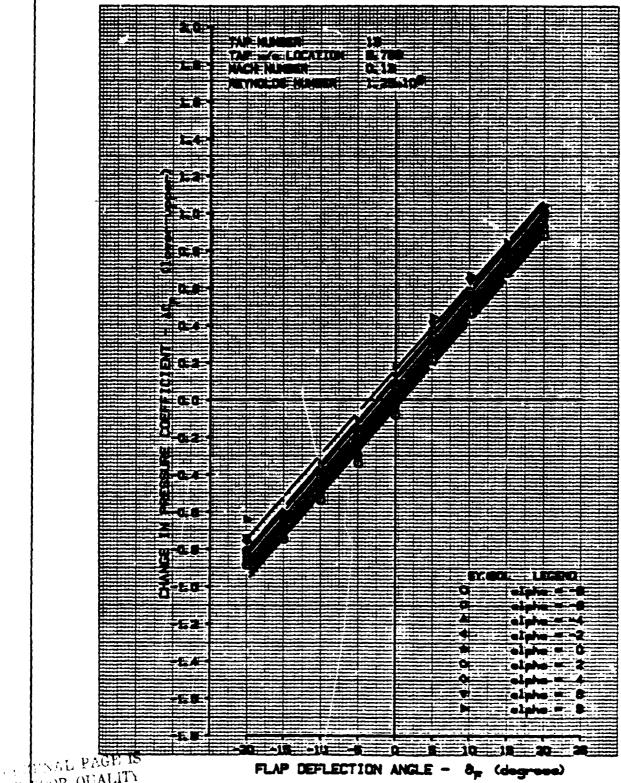
HOTE: LOWER SURFACE C. INTERPOLATED TO UPPER SURFACE TAP LOCATION



FLAP DEFLECTION ANGLE - 8, (degrees)

CALC	P. FINN	5-01	REVISED	DATE	FIGURE A. 1. 12	EXPERIMENTAL CHANGE IN	DATE
CHECK	D. LEYY	5/28/81				PRESSURE COEFFICIENTS	21-5-61
APPD						- FLAP DEFLECTION SENSITIVITY	
APPO					<u> </u>	32113212721	
					UNIVE	RSITY OF KANSAS	FAGE 69

NOTE: LOWER SUMFACE CO INTERPOLATED TO UPPER SUMFACE TAP LOCATION



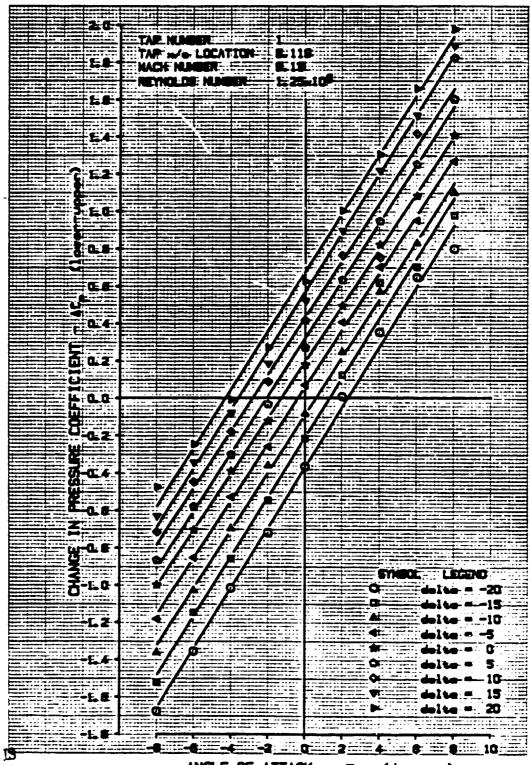
FLAP DEFLECTION ANGLE - 8, (degrees)

CALC	P. FINN	5-01	REVISED	DATE	FIGURE A. 1. 13 EXPERIMENTAL CHANGE IN	DATE
CHECK	D. LEVY	5/25/4			PRESSURE COEFFICIENTS	21-5-01
APPO					- FLAP DEFLECTION SENSITIVITY	
APPO						PAGE _
					University of Kansas	PAGE 70

OF POOR QUALITY

A.2 ANGLE OF ATTACK

NOTE: LOWER SURFACE C. INTERPOLATED TO UPPER SURFACE TAP LOCATION

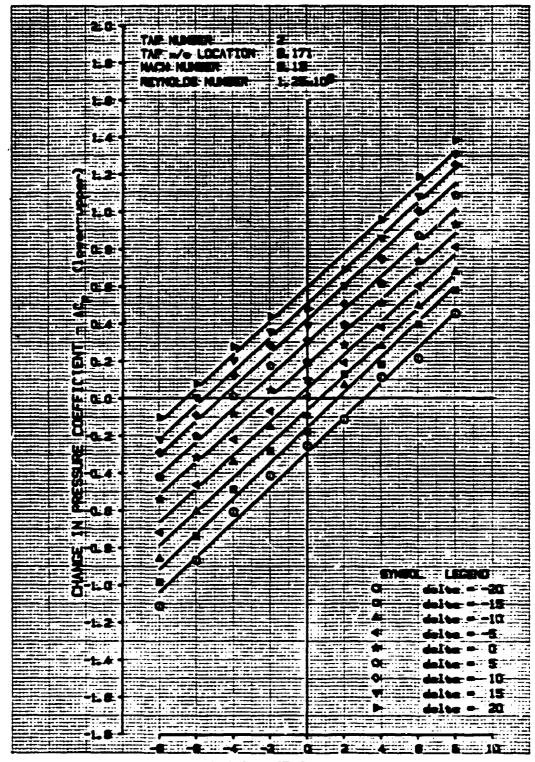


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ANGLE OF ATTACK - CE (degrees)

CALC	P. FINN	5-61	REVISED	DATE	FIGURE A. 2. 1 EXPERIMENTAL CHANGE IN	DATE
CHECK	D. LEVY	5/25/4			PRESSURE COEFFICIENTS	29-5-01
APPO					- ANGLE OF ATTACK SENSITIVITY	
APPO						PAGE
					UNIVERSITY OF KANSAS	72

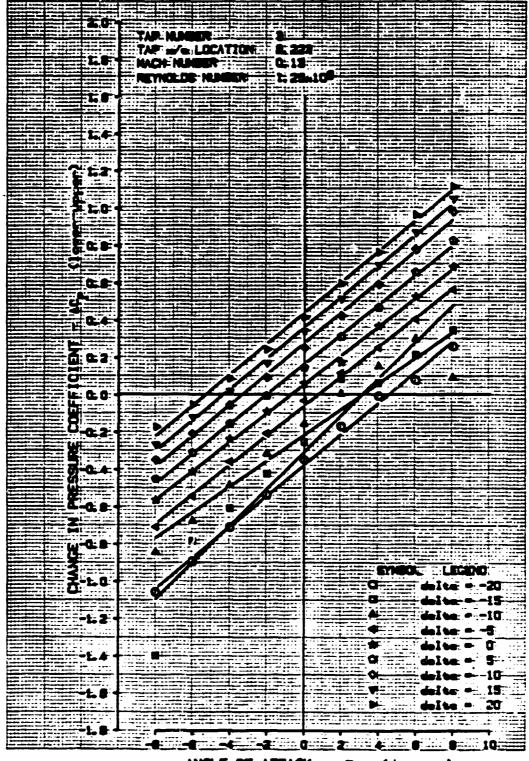
NOTE: LONGR SUPPACE CP INTERPOLATED TO UPPER SUPPACE TAP LOCATION



ANGLE OF ATTACK - Œ (degrees)

APPO					UNIVERSITY OF KANSAS	PAGE 73
APPO					SENSITIVITY	
CHECK	DILEVY	5/25/61			PRESSURE COEFFICIENTS - ANGLE DE ATTACK	20-5-61
عاشا	P. FINN	5-01	AEVISED	DATE	FIGURE A. 2. 2 EXPERIMENTAL CHANGE IN	DATE

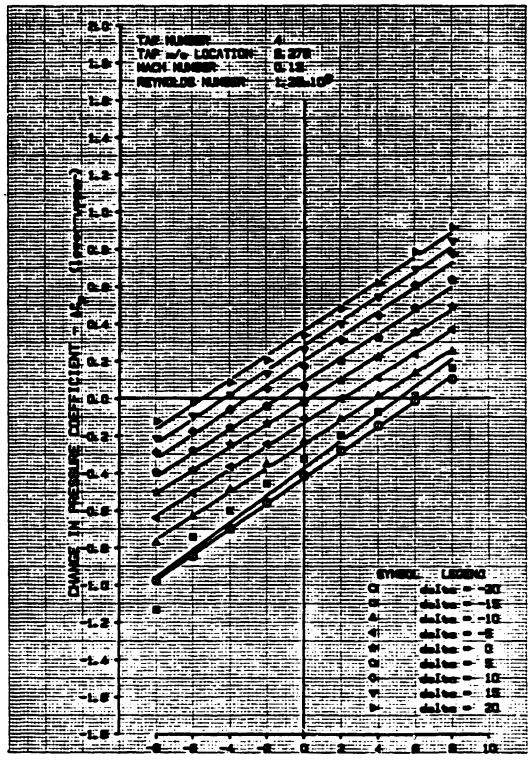
NOTES LOWER SURFACE CO INTERPOLATED TO UPPER SURFACE TAP LOCATION



ANGLE OF ATTACK - CE (degrees)

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CALCA IJ.	LEVY 5/25/4		PRESSURE COEFFICIENTS - ANGLE OF ATTACK	20-5-61
APPO			SENSITIVITY	
APPO		<u></u>	UNIVERSITY OF KANSAS	PAGE 7

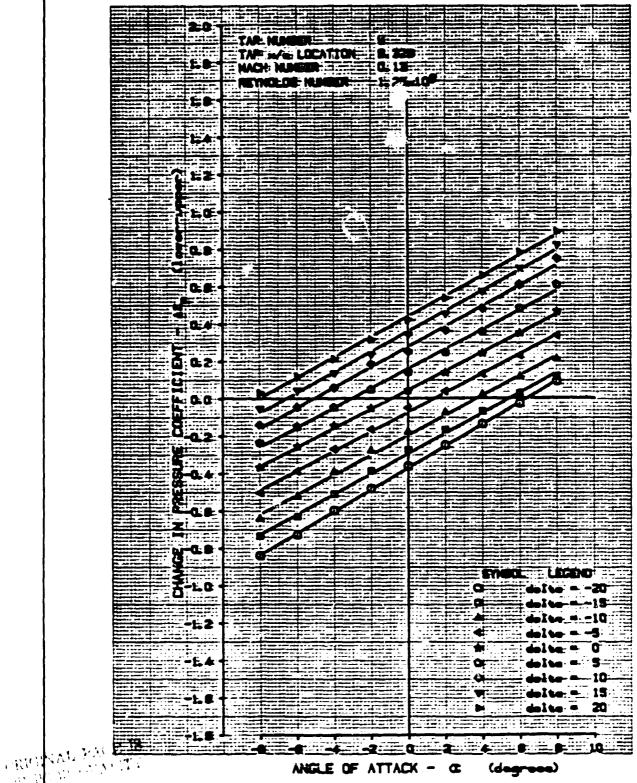
NOTE: LONGR SUFFACE CP INTERPOLATED TO UPPER SUFFACE TAP LOCATION



ANGLE OF ATTACK - C (degrees)

CALC	P. FINN	5-01	REVISED	DATE	FIGURE A. 2. 4 EXPERIMENTAL CHANGE IN	DATE
CHECK	D. LEVY	5/22/91			PRESSURE COEFFICIENTS - ANGLE OF ATTACK	20-6-01
APPO					SENSITIVITY	ĺ
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L					University of Kansas	/3

NOTE: LOWER SUFFACE C. INTERPOLATED TO UPPER SUFFACE TAP LOCATION

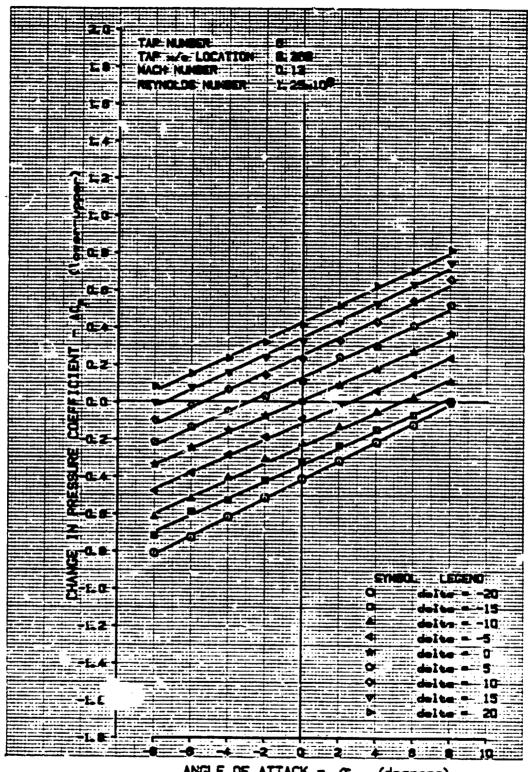


ANGLE OF ATTACK - Œ (degrees)

CALC	P. FINN	5-01	AEVISED	DATE	FIGURE A. 2.5 EXPERIMENTAL CHANGE IN	
CHECK	D' LEVY	5/25/81			PRESSURE COEFFICIENTS - /NGLE OF ATTACK	20-5-01
APPO					SENSITIVITY	
1000				ļ	UNIVERSITY OF KANSAS	*AGE 76
				<u> </u>	UNIVERSITY OF KANSAS	

11.

LOWER SURFACE Co INTERPOLATED TO UPPER SURFACE TAP LOCATION



ANGLE OF ATTACK - a: (degrees)

CALC	P. FINN	5-8:	REVISED	DATE	FIGURE A. 2. 8	EXPERIMENTAL CHANGE IN	DATE
CHECK	DILEVY	5/25/81		<u> </u>		PRESSURE COEFFICIENTS	20 -5-0 1
APPD						- ANGLE OF ATTACK SENSITIVITY	
APPO						3613414141	
					UNIVER	ISITY OF KANSAS	PAGE 77

NOTE: LOWER SURFACE CP INTERPOLATED TO UPPER SURFACE TAP LOCATION

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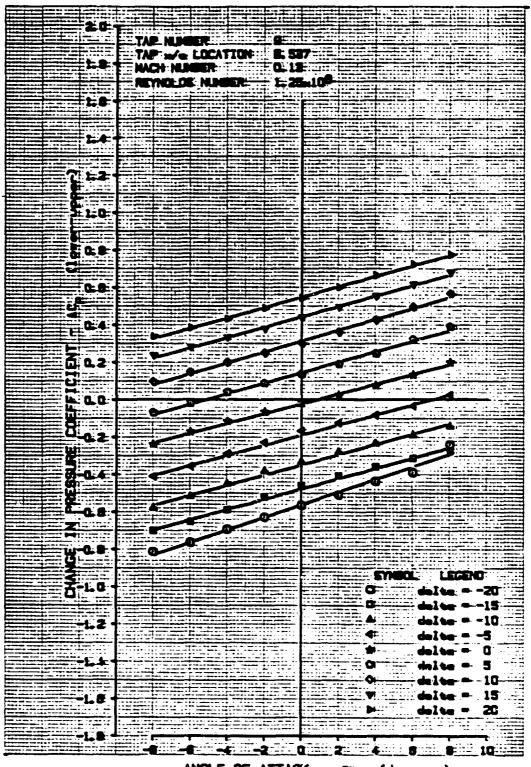
CALC	P. FINN	3-61	AÉVISÉD	CATE	FIGURE A. 2. 7 EXPERIMENTAL CHANGE IN	DATE
CHECK	D. LEVY	5/245)			PRESSURE COEFFICIENTS - ANGLE OF ATTACK	20-5-81
APPO					SENSITIVITY	
APPO						PAGE 78
					UNIVERSITY OF KANSAS	78

NOTE: LOWER SUFFACE CP INTERPOLATED TO UPPER SURFACE TAP LOCATION

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CVFC	p. Finn	- 5 - 81	REVISED	DATE	FIGURE A. 2. 8 EXPERIMENTAL CHANGE IN	DATE
CHECK	D. LEVY	5/25/6/		†	PRESSURE COEFFICIENTS	20-5-81
APPO					- ANGLE OF ATTACK SENSITIVITY	
APPO					UNIVERSITY OF KANSAS	PAGE.

NOTE: LOWER SURFACE CO INTERPOLATED TO UPPER SURFACE TAP LOCATION



ANGLE OF ATTACK - O: (degrees)

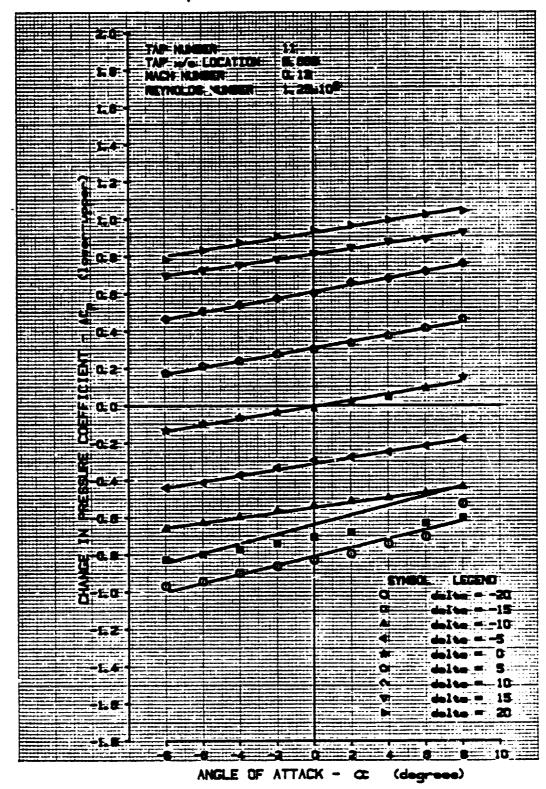
CALC	P. FINN	5-01	REVISED	DATE	FIGURE A. 2. 9 EXPERIMENTAL CHANGE IN	DATE
CHECK	D. LEVY	5/25/81			PRESSURE COEFFICIENTS	21-5-01
APPO					- <u>ANGLE OF ATTACK</u> SENSITIVITY	
APPO						PAGE
					UNIVERSITY OF KANSAS	PAGE 8n

NOTE: LOWER SURFACE CP INTERPOLATED TO UPPER SURFACE TAP LOCATION

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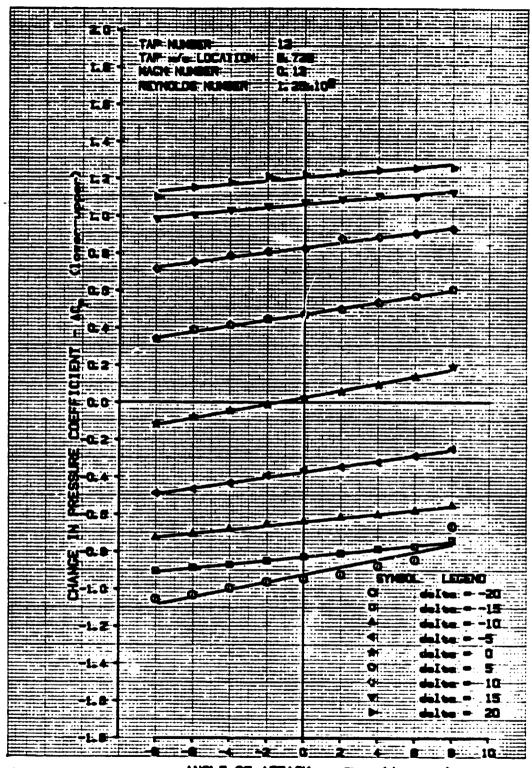
CALC	P. FINN	5-61	REVISED	DATE	FIGURE A. 2. 10 EXPERIMENTAL CHANGE IN	DATE
CHECK	DILEVY	5/25/51			PRESSURE COEFFICIENTS - ANGLE OF ATTACK	21-5-61
APPO					SENSITIVITY	
APPO					UNIVERSITY OF KANSAS	PAGE 81

NOTE: LOWER SURFACE Co INTERPOLATED TO UPPER SURFACE TAP LOCATION



GALC	P. FINN	5-61	REVISED	DATE	FIGURE A. 2. 11	EXPERIMENTAL CHANGE IN PRESSURE COEFFICIENTS	DATE 21-5-01
CHECK	D. LEVY	5/25/8/				- ANGLE OF ATTACK SENSITIVITY	81-3-61
APPO					UNIVE	RSITY OF KANSAS	PAGE 82

NOTE: LOVER SUFFACE C. INTERPOLATED TO UPPER SUFFACE TAP LOCATION

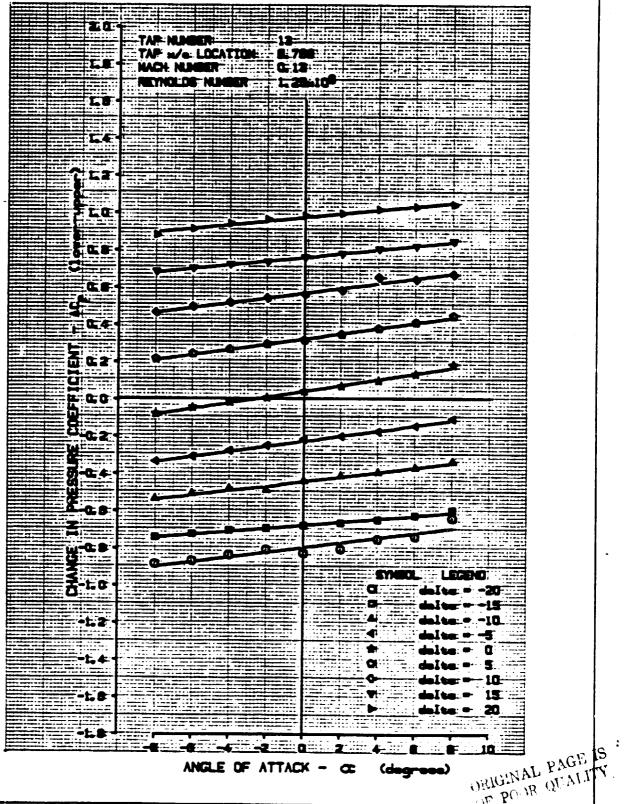


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ANGLE OF ATTACK - CC (degrees)

CALC	P. FINN	5-01	AEVISED	DATE	FIGURE A. 2. 12	EXPERIMENTAL CHANGE IN	DATE
CHECK	D. LEYY	5/25/81				PRESSURE COEFFICIENTS	21-5-61
APPO						- ANGLE OF ATTACK SENSITIVITY	
AP#O							2402
					UNIVI	ERSITY OF KANSAS	PAG83

NOTE: LOWER SUFFACE CO INTERPOLATED TO UPPER SUFFACE TAP LOCATION



ANGLE OF ATTACK - CC (degrees)

OF POOR QUALITY. CALC P. FINN 5-61 REVISED FIGURE A. 2. 13 EXPERIMENTAL CHANGE IN DATE PRESSURE COEFFICIENTS D. LEYY 5/25/81 21-5-81 CHECK - ANGLE OF ATTACK SENSITIVITY APPO PAGE 84 UNIVERSITY OF KANSAS

APPENDIX B. PRESSURE TRANSDUCER CALIBRATION PROGRAM

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245: Wrt 4." THE TRANSDUCER MUST BE HOOKED TO CHANNEL 12 OF THE DAS"
                             THE PRESSURE TRANSDUCER WILL BE CALIBRATED AGAINST THE TUNNEL"
 247: urt 4
 248: wrt 4, "PROCEEDURE: "
 2491 wrt 4
250: wrt 4." TO CALIBRATE, THE TUNNEL WILL BE RUN AT VARIOUS ASSIGNED SPEEDS."
251: wrt 4." THE hp 9825 WILL RECORD THE PRESSURE TRANSDUCER OUTPUT AND "
252: wrt 4." THE OPERATOR WILL ADJUST THE TUNNEL SPEED TO THE MANOMETER VALUE"
253: wrt 4." REQUESTED BY THE CALCULATOR DISPLAY"
 254: urt 4; urt 4
255: ent DATE
                                  TRANSDUCER NUMBER", D.
 256: utb 5,12+6
257: wrt 6; wrt 6; wrt 6; wrt 6; "
258: wrt 6; " ", G$
259: wrt 6; " MANUMETER Q
                                                                                    PRESSURE TRANSDUCER CALIBRATION ", D:
                                                                                   TRANSDUCER OUTPUT"
259: wrt 6," MANOMETER Q IMMODULE QUIFO;
260: csiz 2,2,1,0
261: ent "DO YOU NISH A GRAPH ? Y or N":A$
262: if cap(A$)="Y";csiz 2,2,1,0
263: if cap(A$)="Y";fxd 0;scl 0,35,0,2;/ox 0,.5,0,2,2; ax 0,5,0,35,1
264: if cap(A$)="Y";plt 8,-.5,-1;csiz 2,2,1,0
265: if cap(A$)="Y";plt " TUNNEL DYNAMIC PRESSURE - Q cam Al)"
266: if cap(A$)="Y";plt -5,.6,-1;csiz 2,2,1,90
267: if cap(A$)="Y";plt " TRANSDUCER OUTPUT - Q1 (mY)"
269: if cap(A$)="Y";lb1 " TRANSDUCER OUTPUT - Q1 (mY)"
268: if cap(As)=""""csiz 2.5.2:1.0;plt 5.-.8:-1
269: if cap(As)=""":lb1 " PRESSURE TRANSDUCER CALIBRATION ",Ds
270: if cap(As)=""":plt 2.5,2.4:-1;csiz 2.2.1.0
271: 161
                   "Q = (TUNNEL MANOMETER * SIN30)
272: for Q=0 to 35 by 5
273: fxd 0:0-5
274: dsp "TUNNEL_0 (cmAl)":0:"CONT W/RDY":stp
275: for I=1 to 50
276: red 3,A,B
277: if B>1;-A+A
278: A+S+S
279: next I
280: fmt 4,2x,f4.0,20x,f10.3
281: wrt 6.4.0,20S
282: if cap(A$)="Y"iplt Q,-20SipenicPlt -.165,-.05ilbl "*"
283: next Q
```

APPENDIX C

THEORETICAL PRESSURE PROFILE DATA

PRECEDING PAGE BLANK NOT FILMED

C.1 SAMPLE LISTING OF SEAP OUTPUT

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Common Part IS

C.2 PRESSURE DISTRIBUTION DATA AS INPUT TO HP9825 A

CAUDIONIG PROT. BIJULE NOT FILMED

ANGLE OF ATTACK # FILE NUMBER 34	Ø	FLAP	DEFLECTION	ANGLE =	Ø

******	*******	. * * * * * * * * * * * * * * * * * * *	********	*****
TAP	*	X/C	Cp	Cp
NUMBER	*	location	upper	lower
*****		*******	******	******
	*	0.000	4 400	4 4 5 5
1.5	*	0.060 0.076	-1.198 -1.135	-1.198 -1.135
<u>د</u> ج	* *	0.076 0.084	-1.396	-1.135 -1.396
1 2 3 4 5		0.094	-1.354	-1.354
5	* *	0.108	-1.216	-1.216
•	*	0.100		11616
6	*	0.121	-1.277	-1.277
6 7 8 9 10		0.133	-1.450	-1.450
8	*	0.143	-1.365	-1.365
9	*	.0.155	-1.081	-1.081
10	*	0.169	-0.881	-0.881
	*			
11 12 13	*	0.184	-0.743	-0.743
12	*	0.205	-0.648	-0.648
13 14	*	0.228	-0.572 -0.334	-0.572
15	*	0.250 0.381	-0.364 -0.264	-0.334 -0.264
¥.U	*	0.301	T0.254	70.404
16	*	Ø.416	-0.136	-0.136
16 17 18 19	*	0.480	-0.115	-0.115
18	*	0.680	-0.103	-0.363
19	*	0.715	-0.076	-0.076
20	*	0.750	-0.070	-0.079
	*			
21 22 23	*	0.785	-0.042	-0.042
22	•	0.820	-0.029	-0.029
23	*	1.000	0.634	0.634
	•			
*****		******	******	*****

ANGLE OF ATTACK = FILE NUMBER 35	3	FLAP DEFLECTION ANGLE = 0
*******	****	*************

*****	******	*******	****	*****	*******
TAP	X	x/c		aĴ	Cp
NUMBER	*	location		upper	lower
*****	*****	********	*****	******	*******
	*				
1	*	0.060	-	-1.860	-0.612
2	*	0.076	-	-1.728	-0.603
3	*	0.084	-	-1.989	-0.849
1 2 3 4 5	*	0.094	-	-1.877	-0.854
5	*	0.108	-	-1.665	-0.777
	*				
ε	*	0.121	-	-1.702	-0.855
7	*	0.133	-	-1.887	-1.019
6 7 8 9 10	*	0.143	-	-1.786	-0.965
9	*	0.155		-1.445	-0.744
10	*	0.169	-	-1.192	-0.591
-	*				
11	¥	0.184	-	-1.009	-0.490
12 13	x	0.205	-	-0.881	-0.423
13	X	0.228	-	-0.788	-0.364
14	÷	0.250		-0.476	-0.193
15	*	0.381	• .	-0.381	-0.145
	* .				
16	*	0.416	-	-0.209	-0.057
17	*	0.480	-	-0.177	-0.050
18	*	0.680	•	-0.159	-0.045
19	*	0.715	-	-0.119	-0.035
20	*	0.750	-	-0.115	-0.028
	*	-			
21	*	0.785	-	-0.080	-0.006
22	*	0.820		-0.063	-0.002
23	*	1.000		0.630	0.630
	*				

ANGLE OF ATTACK = 6 FLAP DEFLECTION ANGLE = 0 FILE NUMBER 36

*****	***	*******************	*****	******
TAP	*	x/c	Cp	a3
NUMBER	*	location	upper	lower
*****	***	*************	*****	*************
	*			
1	*	0.060	-2.624	-0.093
2	*	0.076	-2.407	-0.124
3	*	0.084	-2.670	~0.345
1 2 3 4 5	*	0.094	-2.489	~0.382
5	*	0.108	-2.190	-0.355
	X			
6 7 8 9 10	*	0.121	-2.194	-0.444
7	*	0.133	-2.383	-0.598
8	*	0.143	-2.240	-0.578
9	*	0.155	-1.822	-0.418
10	*	0.169	-1.512	-0.308
	*			
11	*	0.184	-1.283	-0.240
12	×	0.205	-1.121	-0.198
13	*	0.228	-1.008	-0.156
12 13 14	*	0.250	-0.626	-0.047
15	*	0.381	-0.510	-0.018
	*			
16 17	*	0.416	-0.298	0.033
17	*	0.480	-0.248	0.026
18	*	0.680	-0.221	0.022
19	*	0.715	-0.163	0.016
20	*	0.750	-0.162	0.024
	*			
21 22	*	0.785	-0.119	0.039
22	*	0.820	-0.096	0.036
23	*	1.000	0.624	0.624
	*			
****	***	*********	*******	******

ANGLE OF ATTACK = FILE NUMBER 37	0	FLAP DEFLECTION ANGLE = 5
********	*******	**********

*****	*****	*******	********	**********
TAP	*	x/c	අර	අර
NUMBER		location	tegau.	lower
******	*****	*******	*******	**********
	*			
1	*	0.062	-1,340	-1.022
2	*	0.073	-1.285	-0.949
1 2 3 4 5	*	0.083	-1.572	-1.148
4	*	0.094	-1.501	-1.202
5	*	0.107	-1.359	-1.063
	*			
6	*	0.123	-1.486	-1.116
7	*	0.135	-1.627	-1.266
8	*	0.143	-1.324	-1.146
ģ	*	0.163	-1.032	-0.886
6 7 8 9 10	*	0.181	-0.903	-0.714
•	*			
11	*	0.293	-0.596	-0.436
12	*	0.296	-0.418	-0.275
12 13	÷	0.404	-0.214	-0.076
14	*	0.652	-0.158	-0.008
15	*	0.671	-0.027	0.215
	*		<u> </u>	-
16	* .	0.688	-0.060	0.157
16 17	*	0.704	-0.039	0.144
18	*	0.720	0.020	0.124
19	*	0.741	-0.022	0.068
20	*	0.795	-0.067	0.033
	*	••••		
21	*	0.824	-0.043	0.008
22	*	0.852	-0.102	-0.088
23	*	1.000	0.760	0.760
_~	 *	*****		

ANGLE OF ATTACK = 3 FLAP DEFLECTION ANGLE = 5 FILE NUMBER 38

*****	****	******************	*****	**********
TAP	*	x/c	Cp	aű
NUMBE	R *	location	upper	lower
*****	****	************	*** * *****	***********
	*			
1	*	0.062	-1.607	-0.748
2	*	0.073	-1.513	-0.712
3	* * *	0.083	-1.803	-0.912
1 2 3 4 5	*	0.094	-1.703	-0.984
5	*	0.107	-1.524	-0.881
	*			
67 8 9 10	*	0.123	-1.632	-0.951
7	*	0.135	-1.767	-1.107
8	* * *	0.148	-1.452	-1.006
9		0.163	-1.141	-0.773
10	X	0.181	-1.001	-0.619
	×			
11	*	0.203	-0.644	-0.384
12 13	*	0.296	-0.438	-0.250
13	*	0.404	-0.178	-0.105
14	*	0.65 2	-0.097	-0.060
15	*	0.671	0.122	0.078
	*			
16 17	*	0.688	0.091	0.009
17	*	0.704	0.123	-0.020
18	÷	0.720	0.158	-0.022
19	*	0.741	0.080	-0.039
20	*	0.795	0.017	-0.053
	*			
21	*	0.824	0.039	-0.077
22	*	0.852	-0.024	-0.174
23	*	1.000	0.750	0.750
	*			
*****	****	**************************************	*******	*******

ANGLE OF ATTACK = FILE NUMBER 39	6	FLAP DEFLECTION ANGLE = 5
*********	*****	**********

RESULTS OF SEAP DATA

- ∴				
****	****	***********		******
TAP	X	×/c	Cp	Cp
NUMBER		location	upper	lower
*****	****	***********	******	************
	X			
1	*	0.062	-1.905	-0.469
2	*	0.073	-1.773	-0.464
1 2 3 4 5	*	0.083	-2.063	-0.661
4	*	0.094	-1.925	-0.748
5	*	0.107	-1.707	-0.680
	*			
6	*	0.123	-1.798	-0.764
7	X	0.135	-1.914	-0.932
8	*	0.148	-1.563	-0.860
6 7 8 9	*	0.163	-1.230	-0.652
10	*	0.181	-1.083	-0.512
	*			
11	*	0.203	-0.688	-0.318
12	÷	0.296	-0.456	-0.209
13	*	0.404	-0.140	-0.119
14	*	0.652	-0.035	-0.098
15	*	0.671	0.261	-0.040
-	*		** - = =	
16	*	0.688	0.254	-0.145
17	*	0.704	0.307	-0.209
18	*	0.720	0.319	-0.192
19	*	0.741	0.199	-0.158
20	*	0.795	0.113	-0.150
	*			
21	X	0.824	0.130	-0.168
22	*	0.852	0.045	-0.281
23	*	1.000	0.725	0.725
	*			
*****	*****	*******	******	**********

.

ANGLE OF ATTACK = 9 FLAP DEFLECTION ANGLE = 5 FILE NUMBER 48

****	*****	*******	*******	******
TAP	*	x/c	a)	qΰ
NUMBER	* 1	ocation	upper	lower
	_		**********	
	\ 			
1	*	0.062	-2.268	-0.158
1 2 3 4 5	*	0.073	-2.088	-0.183
3		0.083	-2.376	-0.372
4	* *	0.094	-2.194	-0.471
5	*	0.107	-1.928	-0.438
•	*	0110	••••	01100
6	*	0.123	-1.997	-0.533
Ž	*	0.135	-2.091	-0.701
8	*	0.148	-1.699	-0.658
6789	*	0.163	-1.338	-0.488
10	*	0.181	-1.185	-0.369
	*			
11	*	0.203	-0.754	-0.215
11 12	*	0.295	-0.498	-0.132
13	*	0.404	-0.126	-0.091
14	*	0.652	-0.002	-0.081
15	*	0.671	0.322	-0.017
	*		0.00	2.02.
16	*	0.688	0.384	-0.286
17	*	0.704	0.488	-0.503
18	*	0.720	0.482	-0.472
19	*	0.741	0.316	-0.327
20	ņė	0.795	0.205	-0.276
	*			~ · · · ·
21	*	0.824	0.214	-0.275
21 22	*	0.852	0.096	-0.407
23	*	1.000	0.683	0.683
	*			
****	******	*******	******	******

ANGLE O		ACK = 0 40	FLAP DEFLEC	FION ANGLE = 10
******	****	*******	*******	******
••	<u>.</u> -	RESULTS 0	OF SEAP DATA	
****	****	*******	*******	******
TAP	*	x/c	Cp	aO
NUMBER		location	upper	lower
****		******	******	****
	*		4 545	
1	*	0.060	-1.945	-0.541
234 5	*	0.071	-1.856	-0.493
ي ه	*	0.081	-2.166	-0.534
4	*	0.091 0.102	-2.055 -1.832	-0.747 -0.725
J	⊼ X	0.102	71.002	-0.723
E	*	0.116	-1.928	-0.668
7	*	0.128	-2.110	-0.000 -0.767
ģ	*	0.140	-1.960	-0.887
6789	*	0.151	-1.613	-0.771
10	*	0.165	-1.370	-0.562
• •	*	0.1.00		0.002
11	*	0.180	-1.263	-0.444
12	*	0.199	-0.932	-0.241
13	*	0.278	-0.683	-0.101
14	*	0.399	-0.469	0.068
15	*	0.649	-0.428	0.141
	*			
16	*	0.672	-0.527	ย.364
17	*	0.688	-0.622	0.331
18	*	0.704	-0.685 7	0.317,
19	*	0.720	U • C 27 ,	0.188
20	*	0.844	-0.213	0.158
21	*	0.070	0.070	0.107
21 22 23	* *	0.873 0.901	-0.072 0.027	0.127 0.105
22	₹ X	1.001	0.027 0.170	0.105 0.170

ANGLE OF ATTACK = 3 FLAP DEFLECTION ANGLE = 10 FILE NUMBER 41

**************************************	***	×/c	C	a a	**************************************
NUMBER	. *	location		oper 	lower
*****	***	*************	***	****	*****
	*	0.000	_	701	0.000
1 2 3 4 5	*	0.060		761	0.020
2	*	0.071		588	0.006
3	*	0.081		922	-0.063
4	*	0.091		744	-0.245
5	*	0.102	-2.	430	-0.265
_	*			-	2.252
67 8 9 10	* * *	0.116		507	-0.252
7	*	0.128		685	-0.3 <u>5</u> 3
8	*	0.140		476	-0.469
9		0.15 <u>1</u>		048	-0.400
10	*	0.165	-1.	748	-0.252
	*				
11	*	0.180		617	-0.168
12 13	×	0.199		200	-0.033
13		0.278		883	0.057
14	*	9.399		588	0.165
15	*	0.649	-0.	519	0.215
	*				
16 17	*	0.672	-0.	566	0.400
17	×	0.688	-0.	671	0.377
18	*	0.704	-0.	730 7	0.3617
19		0.720	-0.	.331 💪	0.230 (
20	*	0.844	-0.	247	0.199
	*				
21 22	÷	0.873		096	0.159
22	*	0.901	0.	010	0.128
23	÷	1.001	ø.	165	0.165
	×				
*****	* * *	*******	***	****	*******

MELTA P PROJECT - PHASE I

SINGLE ELEMENT AIRFOIL PROGRAM RESULTS

ANGLE OF ATTACK =	6	FLAP DEFLECTION ANGLE = 10
FILE NUMBER 42		

*****	* *	*** ***************	******	*******
TAP	×	x/c	a)	a)
NUMBER	*	location	upper	lower
*****	**	`	*********	************
	*			
1	÷	0.060	-3.655	0.459
2	÷	0.071	-3.384	0.409
1 2 3 4 5	÷	0.081	-3.737	0.327
4	×	0.091	-3.476	0.178
5	*	0.102	-3.060	0.130
	÷			
6	*	0.116	-3.111	0.112
Ž	Ť	0.128	-3.279	0.014
8	*	0.140	-2.999	-0.100
6789	×	0.151	-2.483	-0.072
: ១	*	0.165	-2.128	0.028
•	*			
11	¥	0.180	-1.979	0.084
12	×	0.199	-1.476	0.160
13	÷	0.278	-1.090	0.208
14	*	0.399	-0.707	0.262
15	*	0.649	-0.606	0.291
	*			
16	¥	0.672	-0.600	0.437
17	×	0.688	-0.717	0.424
18	÷	0.704	-0.771	0.407
19	×	0.720	-0.364	0.276
20	÷	0.844	-0.277	0.242
	×			
21	¥	0.873	-0.116	0.194
22	*	0.901	-0.003	0.153
23	*	1.001	0.163	0.163
	*		<u> </u>	
*****	**	********	*********	******

ANGLE OF ATTACK = 9 FLAP DEFLECTION ANGLE = 10 FILE NUMBER 46

*******	***********		****************	*****			
TAP	*	X/C	Ce	Ce			
NUMBER		ocation	upper	lower			
*****	*******	******	*******				
	*						
1	*	0.060	-4.614	0.771			
1 2 3 4 5	* * *	0.071	-4.232	0.711			
3	*	0.081	-4.594	0.632			
4	*	0.091	-4.240	0.517			
5	*	0.102	-3.708	0.456			
_	*						
6 7 8 9	* *	0.116	-3.724	0.417			
7	*		-3.871	0.327			
ន្	*	0.140	-3.518	0.225			
9	*	0.151	-2.909	0.221			
10	*	0.165	-2.492	0.272			
4.4	*	0.400	0.006	0.004			
11	* *	0.180	-2.326	0.301			
12		0.199	-1.753	0.334			
13	*	0.278	-1.301	0.349			
14	* *	0.399	-0.833 -0.704	0.359			
15	*	0.650	-0.704	0.372			
4.5	* . *	0 670	~0. 668	0.488			
16 17		0.672 0.688	-0.776	ย.400 ย.483			
18	* *	0.764	-0.776	0.467			
19	*	0.720	-0.398	0.457 0.330			
20	⊼ *	0.844	-0.308	0.330 0.294			
20	*	0.077	-0.300	0.274			
21	⊼ ≚	0.873	-0.135	0.237			
22	* *	0.901	-0.135 -0.016	0.185			
23	*	1.001	0.160	0.160			
	*		A1100	01100			

ANGLE OF ATTACK = FILE NUMBER 43	0	FLAP DEFLECTION ANGLE	= 15
******	*****	********	*****

RESULTS OF SEAP DATA

*****	***	************	******	************
TAP	*	x/c	Çp	C P
NUMBER	*	location	upper	lower
****	* * * *	*******	*****	**********
	*			
1	*	0.073	-2.507	-0.227
2	×	0.085	-2.529	-0.298
3	*	0.098	-2.256	-0.423
1 2 3 4 5	*	0.114	-2.350	-0.409
5	*	0.128	-2.522	-0.477
	*			
6	X	0.142	-2.133	-0.584
7	*	0.157	-1.715	-0.457
6 7 8 9	*	0.175	-1.479	-0.288
9	¥	0.197	-1.357	-0.214
10	*	0.222	-0.903	0.011
	*			
11	*	0.367	-0.781	0.073
12	*	0.416	-0.608	0.217
13	*	0.607	-0.616	0.254
13 14	*	0.632	-0.718	0.406
15	*	0. F	-0.750	0.418
	¥			
16	*	0.674	-0.945	0.444
17	×	0.695	-1.061	0.449
18 19	* *	0.715	-0.913	0.449
19	*	0.735	-0.269	0.248
20	*	0.916	-0.157	0.201
	*			
21	*	0.947	0.152	0.079
22	*	0.977	0.247	0.983
23	*	1.003	0.151	0.151
	*			
*****	***	******	*****	********

ANGLE OF ATTACK = 3 FLAP DEFLECTION ANGLE = 15 FILE NUMBER 44

RESULTS OF SEAP DATA

NUMBER * location upper lower	

*	
1 * 0.073 -3.224 0.190 2 * 0.085 -3.193 0.103 3 * 0.698 -2.815 -0.025 4 * 0.114 -2.874 -0.048 5 * 0.128 -3.036 -0.129	
2 * 0.085 -3.193 0.103 3 * 0.098 -2.815 -0.025 4 * 0.114 -2.874 -0.048	
3 * 0.098 -2.815 -0.025	
4 * 0.114 -2.874 -0.048	
* * * * * * * * * * * * * * * * * * * *	
6 * 0.142 -2.586 -0.235	
7 * 0.157 -2.103 -0.156	
6 * 0.142 -2.586 -0.235 7 * 0.157 -2.103 -0.156 8 * 0.175 -1.819 -0.041 9 * 0.197 -1.687 0.009	
9 * 0.197 -1.687 0.009	
10 * 0.222 -1.114 0.154	
*	
11 * 0.367 -0.959 0.193	
11 * 0.367 -0.959 0.193 12 * 0.416 -0.711 0.288 13 * 0.607 -0.703 0.315	
13 * 0.607 +0.703 0.315 14 * 0.631 +0.762 0.439	
15 * 0.65 4 - 0. 787 0.45 4	
10 * 0.004 - 0. (0) 0.404	
16 * 0.674 -0.960 0.477	
16 * 0.674 -0.960 0.477 17 * 0.695 -1.061 0.481 18 * 0.715 -0.913 0.482 19 * 0.735 -0.280 0.275	
18 * 0.715 -0.913 0.482	
19 * 0.735 -0.280 0.275	
20 * 0.916 -0.166 0.224	
*	
21 * 0.947 0.150 0.079	
21 * 0.947 0.150 0.079 22 * 0.977 0.241 0.070 23 * 1.003 0.143 0.143	
23 * 1.003 0.143 0.143	
*	
**************************************	****

MANSAS UNIVERSITY FLIGHT RESEARCH LAB

SINGLE ELEMENT AIRFOIL PROGRAM RESULTS

RESULTS OF SEAP DATA TAP		F ATTACK = MBER 45	6	FLAP DEFLECTION	ANGLE = 15
TAP * x/c CP CP CP NUMBER * location upper lower 1 * 0.073	*****	*****	******	******	*********
TAP * x/c			RESULTS OF	SEAP DATA	
NUMBER * location upper lower ***********************************	****	*************	******		

* 0.073					
1 * 0.073 -4.040 0.539 2 * 0.085 -3.951 0.448 3 * 0.098 -3.454 0.328 4 * 0.114 -3.475 0.280 5 * 0.128 -3.614 0.193 6 * 0.128 -3.061 0.087 7 * 0.157 -2.491 0.121 8 * 0.175 -2.160 0.193 9 * 0.197 -2.017 0.224 10 * 0.222 -1.329 0.296 11 * 0.327 -1.144 0.316 12 * 0.416 -0.819 0.364 13 * 0.607 -0.792 0.382 14 * 0.631 -0.812 0.479 15 * 0.655 -0.840 0.497 * 0.695 -1.087 0.524 19 * 0.715 -0.936 0.524 19 * 0	*****		*****	**************************************	*********
2 * 0.085	•		972	-4 040	0 500
5 * 0.128 -3.614 0.193 6 * 0.142 -3.061 0.087 7 * 0.157 -2.491 0.121 8 * 0.175 -2.160 0.193 9 * 0.197 -2.017 0.224 10 * 0.222 -1.329 0.296 11 * 0.327 -1.144 0.316 12 * 0.416 -0.819 0.364 12 * 0.416 -0.819 0.364 13 * 0.607 -0.792 0.382 14 * 0.631 -0.812 0.479 15 * 0.655 -0.840 0.497 * 0.655 -0.840 0.497 * 0.695 -1.087 0.521 18 * 0.715 -0.936 0.524 19 * 0.735 -0.292 0.311 20 * 0.916 -0.175 0.257 * 0.947 0.155	2				
5 * 0.128 -3.614 0.193 6 * 0.142 -3.061 0.087 7 * 0.157 -2.491 0.121 8 * 0.175 -2.160 0.193 9 * 0.197 -2.017 0.224 10 * 0.222 -1.329 0.296 11 * 0.327 -1.144 0.316 12 * 0.416 -0.819 0.364 12 * 0.416 -0.819 0.364 13 * 0.607 -0.792 0.382 14 * 0.631 -0.812 0.479 15 * 0.655 -0.840 0.497 * 0.655 -0.840 0.497 * 0.695 -1.087 0.521 18 * 0.715 -0.936 0.524 19 * 0.735 -0.292 0.311 20 * 0.916 -0.175 0.257 * 0.947 0.155	3				
5 * 0.128 -3.614 0.193 6 * 0.142 -3.061 0.087 7 * 0.157 -2.491 0.121 8 * 0.175 -2.160 0.193 9 * 0.197 -2.017 0.224 10 * 0.222 -1.329 0.296 11 * 0.327 -1.144 0.316 12 * 0.416 -0.819 0.364 12 * 0.416 -0.819 0.364 13 * 0.607 -0.792 0.382 14 * 0.631 -0.812 0.479 15 * 0.655 -0.840 0.497 * 0.655 -0.840 0.497 * 0.695 -1.087 0.521 18 * 0.715 -0.936 0.524 19 * 0.735 -0.292 0.311 20 * 0.916 -0.175 0.257 * 0.947 0.155	4				
6 * 0.142	5	* 0		-3.614	0.193
7 * 0.157					
10 * 0.222 -1.329 0.296 11 * 0.327 -1.144 0.316 12 * 0.416 -0.819 0.364 13 * 0.607 -0.792 0.382 14 * 0.631 -0.812 0.479 15 * 0.655 -0.840 0.497 * * 0.674 -0.997 0.518 17 * 0.695 -1.087 0.521 18 * 0.715 -0.936 0.524 19 * 0.735 -0.292 0.311 20 * 0.916 -0.175 0.257 * 0.947 0.155 0.092 22 * 0.977 0.246 0.069 23 * 1.003 0.145 0.145	6				
10 * 0.222 -1.329 0.296 11 * 0.327 -1.144 0.316 12 * 0.416 -0.819 0.364 13 * 0.607 -0.792 0.382 14 * 0.631 -0.812 0.479 15 * 0.655 -0.840 0.497 * * 0.674 -0.997 0.518 17 * 0.695 -1.087 0.521 18 * 0.715 -0.936 0.524 19 * 0.735 -0.292 0.311 20 * 0.916 -0.175 0.257 * 0.947 0.155 0.092 22 * 0.977 0.246 0.069 23 * 1.003 0.145 0.145	7				
10 * 0.222 -1.329 0.296 11 * 0.327 -1.144 0.316 12 * 0.416 -0.819 0.364 13 * 0.607 -0.792 0.382 14 * 0.631 -0.812 0.479 15 * 0.655 -0.840 0.497 * * 0.674 -0.997 0.518 17 * 0.695 -1.087 0.521 18 * 0.715 -0.936 0.524 19 * 0.735 -0.292 0.311 20 * 0.916 -0.175 0.257 * 0.947 0.155 0.092 22 * 0.977 0.246 0.069 23 * 1.003 0.145 0.145	8				
* 0.327					
11 * 0.327 -1.144 0.316 12 * 0.416 -0.819 0.364 13 * 0.607 -0.792 0.382 14 * 0.631 -0.812 0.479 15 * 0.655 -0.840 0.497 * 16 * 0.674 -0.997 0.518 17 * 0.695 -1.087 0.521 18 * 0.715 -0.936 0.524 19 * 0.735 -0.292 0.311 20 * 0.916 -0.175 0.257 * 21 * 0.947 0.155 0.992 22 * 0.947 0.145	10		.222	-1.329	0.296
15 * 0.655	11		227	-1 14A	0.216
15 * 0.655	12	* 0		-0.819	
15 * 0.655	13	÷ A			
15 * 0.655	14	* 0			
* 0.674	15				
17 * 0.695 -1.087 0.521 18 * 0.715 -0.936 0.524 19 * 0.735 -0.292 0.311 20 * 0.916 -0.175 0.257 * 21 * 0.947 0.155 0.992 22 * 0.977 0.246 0.069 23 * 1.003 0.145 0.145					
18 * 0.715 -0.936 0.524 19 * 0.735 -0.292 0.311 20 * 0.916 -0.175 0.257 * * 21 * 0.947 0.155 0.092 22 * 0.977 0.246 0.069 23 * 1.003 0.145 0.145					
19 * 0.735 -0.292 0.311 20 * 0.916 -0.175 0.257 * 21 * 0.947 0.155 0.992 22 * 0.977 0.246 0.069 23 * 1.003 0.145 0.145			.695		0.521
20 * 0.916 -0.175 0.257 * 0.947 0.155 0.992 22 * 0.977 0.246 0.069 23 * 1.003 0.145 0.145		* 0	.715		
* 21 * 0.947 0.155 0.092 22 * 0.977 0.246 0.069 23 * 1.003 0.145 0.145					
21 * 0.947 0.155 0.092 22 * 0.977 0.246 0.069 23 * 1.003 0.145 0.145	20		.916	-0.175	0.25 7
22 * 0.977 0.246 0.069 23 * 1.003 0.145 0.145	21		947	0 155	A A45
23 ÷ 1.003 0.145 0.145	20				
*	22	⊼ U			
	20		. 000	91179	च • • Tच'



ANGLE OF ATTACK = 9 FLAP DEFLECTION ANGLE = 15 FILE NUMBER 47

RESULTS OF SEAP DATA

TAP	*	x/c	۾ڷ	Cp
UMEER	÷	location	upper	lower
****	*****	*******	*****	******
	X			
1	*	0.073	-4.897	0.791
1 2 3 4	*	0.085	-4.740	0.711
3	*	0.098	-4.113	0.608
4	*	0.114	-4.090	0.548
5	*	0.128	-4.203	0.464
	*			
6	*	0.142	-3.550	0.367
7	*	0.157	-2.891	0.365
6 7 8 9	*	0.175	-2.504	0.394
9	*	0.970	-2.343	0.405
10	*	0.222	-1.530	0.424
	*			
11	*	0.367	-1.310	0.427
12	*	0.416	-0.912	0.439
13	*	0.607	-0.874	0.450
14	*	0.632	-0.869	0.531
15	*	0.655	-0.898	0.554
_	* .			
16	*	0.674	-1.044	0.574
17	*	0.695	-1.123	0.574
13	*	0.715	-0.967	0.577
19	*	0.735	-0.304	0.356
20	*	0.916	-0.181	0.297
	*			
21	*	0.947	0.163	0.109
22	*	0.977	0.253	0.070
23	×	1.003	0.146	0.146
	 *		- - · -	

```
## "DELTA P THEORETICAL PRESSURE DISTRIBUTION DATA STORER":
   1: dim X[3,3,33],U[3,3,33],L[3,3,33],N$[1],Y$[1]
  2: fmt 1:2:2x:f8.5
3: for I=1 to 3
  4: for J=1 to 3
5: wrt 4, "ANGLE OF ATTACK=",3(J-1), "DEG"
6: wrt 4, "FLAP_DEFLECTION=",5(I-1), "DEG"
  7: for K=1 to 33
8: ent "X/C?";X[I;J;K]
  9: wrt 4,K,X[I,J,K]
  10: next K
11: ent "CHANGES?", N$
12: if cap(N$)="Y";cll 'changes'(1)
· 13: for K=1 to 33
  14: wrt 4.1:K:X[]:J:K]
15: ent "Cp UPPER?":UC]:J:K]
  16: wrt 4.1; UE 1, J; K ]; wrt 4
17: next K
18: ent "CHANGES?"; N$
19: if cap(N$)="Y"; cll 'changes'(2)
  20: for K=1 to 33
  21: urt 4.1,K;X[1,J;K];U[1,J;K]
22: ent "Cp LOWER?";L[1,J;K]
23: urt 4.1;L[1,J;K];urt 4
  24: next K
25: ent "CHANGES?", N$
26: if cap(N$)="Y"; cll !changes!(3)
  27: 4+r1
  33: wrt 4.1,K,X[I,J,K],U[I,J,K],L[I,J,K];wrt ri
  34: next K
35: ent "GENERAL CHANGES?", Y$
36: if cap(Y$)="Y"; 95b "GC"
37: if cap(N$)="Y"; Jmp 4
  38: ent "HARD COPY OF THIS?", N$
39: if cap(N$) #"Y"; Jmp 3
40: 6+11; to 28
  41: "H"+H$
  421 next J
431 next I
  44: trk 1ifdf 33ircf 33, X[+], U[+], L[+]
 -45: stp
46: "GC":
  52: eto 47
53: "chanees":
54: "N"→N$
  55: ent "NUMBER?",K
56: if pl=1;ent "X/C?",X[I,J,K]
57: if pl=2;ent "Cp UPPER?",U[I,J,K]
58: if pl=3;ent "Cp LOWER?",L[I,J,K]
  59: ent "MORE?", N$
60: if cap(N$)#"Y"; ret
  61: sto 54
  +1442
```

```
0: "SEAP - C SUB P OUTPUTTING PROGRAM files 34+49":
1: dim L#[80]:P#[3];Y#[80];S#[10];for S=1 :o 60;"*"+L#[8];next S;fxd 1
2: dim X(23):U[23];L[23];A;B;" "L#-L#
3: " "+S#
4: fmt 1:10x:f3.0.4x,"+",3f15.3
5: fmt 2:9x;"ANGLE OF ATTACK = ";f4.0:10x;"FLAP DEFLECTION ANGLE = ";f4.0
6: fmt 3:9x:"FILE NUMBER ";f2.0
7: TPCL":ent "FILE NUMBER?";Fi1f F(34 or F)49:been:ato +0
8: trk 13+dr Fildr FrXE*3-UE*3-LE+1-8-B
9: "STR": urt 6."
                                                   *ANSAS UNIVERSITY FLIGHT PESEARCH LAB"; wrt 6
DELTA P PROJECT - PHASE I"
10: urt 6,"
11: urt 6:"
12: NFL 6
13: urt 6."
                                                   SINGLE ELEMENT AIRFOIL PROGRAM RESULTS"
14: wrt 6iurt 6iurt 6iwrt 6.2.A.Biurt 6.3.Fiwrt 6iurt 6:Liiwrt 6
15: wrt 6:Sit Sit RESULTS OF SEAP DATA"
16: urt 6:urt 6:L:
17: urt 6:S:: TAP +'
18: urt 6:S:urt 8:
                                  +"&$$&" x/c
                                                                                                      Cp"
                                                   location
                                                                                                           lover"
                                                                                 upper
19: urt 6.Ls
20: wrt 6. - +-; u+b.
21: wrt 6.1.5: ($1.0($1.1($1:6+1+8
                                                +~:0-6:for 5=1 to 23
221 if B=510+Biurt 61"
23: next Siurt 6:
24: Wrt 6;L3;wrt 6;wrt 6;wrt 6
25: for S=1 to 12;wrt 6;next S
26: ent "ANOTHER FILE?";P3;1f cap(P1)="Y";9to "PCL"
27: SEP
*8319
```

EXANGLE OF ATTACK AND

FLAP DEFLECTION

ANGLE OF ATTACK = 0 FLAP DEFLECTION ANGLE = 0 FILE NUMBER 50

******		***********	*****	*********	*****
TAP	*	×/c	q0	Cp	change in
NUMBER	*	location	upper	lower ********	Cp
1	raar X	0.119	-1.267	-1.267	0.000
2	* *	0.171	-0.859	-0.859	0.000
3	₹ *	0.223	-0.588	-0.588	0.000
4	*	0.276	-0.320	-0.320	0.000
5	*	0.328	-0.292	-0.292	0.000
6	*	0.380	-0.264	-0.264	0.000
7	 * *	0.433	-0.130	-0.130	0.000
8	*	0.485	-0.114	-0.114	0.099
9	* *	0.5 37	-0.111	-0.111	ତ. ଜଣ୍ଡ
10	* *	0.589	-0.108	-0.108	0.009
1 1	* *	0.668	-0.103	-0.103	ଡ. ଅଷଷ
12	* *	0.720	-0.075	-0.075	0.000
13	* *	0.766	-0.058	-0.058	0.000
*****	(* *)	*******	******	*********	******

^{*} Change in pressure coefficient represents the difference between lower and upper surface pressure coefficients

ANGLE N			=	3		FLAP	DEFLECT	ION	ANGLE	=	Ø
*****	****	****	****	***	******	****	(****	***	****	***	***
RESUL	rs of	SEAP	DATE	IN.	TERPOLAT	ED TO	PHASE	I TS	AP LOC	ATIC	ns
*****	•	****		***	******	****		***		., ., ., .,	
TAP NUMBEI	* ₹ *	10	x/c catio	n	a) saau	r	Cp lowe	r	cha	nae Co	in
	****				*****						
1	* *		0.119	1	-1.69	5	-0.84	1	0	. 854	}
2	*		0.171		-1.16	2	-0.57	4	0	. 587	•
3	*		0.223	}	-0.80	7	-0.37	6	0	.431	
4	* *		0.276	;	-0.45	7	-0.18	4	0	. 273	;
5	*		0.328		-0.41	9	-0.16	4	0	.255	;
6	* *		0.380		-0.38	2	-0.14	5	0	.237	
7	*		0.433		-0.20	1	-0.05	5		.145	
•	*				2.23	•	3.30	•	•	• • •	
8	*		0.485		-0.17	7	-0.04	9	0	.127	•
9	 * *		0.537		-0.17	2	-0.04	8	Ø	. 124	•
10	* .		0.589	-	-0.16	7	-0.04	7	Ø	.120	
11	*		0.668		-0.16	0	-0.04	5	0	.115	
12	*	1	0.720		-0.11	8	-0.03	4	0	.084	
13	* *		0.766		-0.10	0	-0.01	8	0	.082	
*****	*	****	****	***	******	****	******	***	****	***	***

^{*} Change in pressure coefficient represents the difference between lower and upper surface pressure coefficients

ANGLE OF ATTACK = 6 FLAP DEFLECTION ANGLE = FILE NUMBER 52 RESULTS OF SEAP DATA INTERPOLATED TO PHASE I TAP LOCATIONS ФĴ СÞ change in TAP X/C NUMBER * lower Cp location rsagu -2.193 -0.429 1.764 1 0.119 ÷ -0.2971.177 2 × 0.171 -1.474÷ -0.1653 0.223 -1.031 0.866 -0.602 -0.0410.561 4 0.276 -0.029 0.527÷ -0.557 5 0.328 -0.511 -0.018 0.493 ¥ 0.380 6 ¥ 0.316 -0.2850.031 7 0.433 0.273 8 × 0.485 -0.248 0.0269 -0.240 0.0250.265 × 0.537 0.024 0.257 10 × 0.589 -0.233 × × -0.222 0.022 0.24511 0.668 0.180 12 0.720-0.163 0.0170.0310.1740.766 -0.143 13

^{*} Change in pressure coefficient represents the difference between lower and upper surface pressure coefficients

ANGLE OF ATTACK = 0 FLAP DEFLECTION ANGLE = 5 FILE NUMBER 53

*****	* * *	******	*****	******	******
TAP	*	x/c	Cp.	Cp	change in
NUMBER	*	location	upper	lower	Cp
*****	***	***********	******	*********	*******
1	*	0.119	-1.455	-1.104	0.352
_	*				
2	*	0.171	-0.973	-0.809	0.165
3	*	0.223	-0.558	-0.401	0.156
•	*	0.22		••••	
4	*	0.276	-0.456	-0.310	0.147
	*				
5	*	0.328	-0.358	-0.216	0.142
	*		6 050	0.400	0.400
6	*	0.380	-0.259	-0.120	0.139
7	*	0.433	-0.208	-0.068	0.140
•	*	31.155			••••
8	*	0.485	-0.196	-0.054	0.142
	*				
9	*	0.5 37	-0.184	-0.040	0.144
4.5	*		0.470	0.005	A 449
10	* *	0.589	-0.172	-0.025	0.147
11	*	0.668	-0.049	0.177	0.226
	*				
12	*	0.720	0.018	0.125	0.107
	*				
13	*	0.766	-0.043	0.052	0.094
******	* • * *		*****	******	*******

^{*} Change in pressure coefficient represents the difference between lower and upper surface pressure coefficients

*****	*****	******	*****	*****	*******
TAP	*	x/c	Cp		change in
NUMBER	*	location	upper	lower	a3
****	*****	******	*****	*****	*****
1	*	0.119	-1.606	-0.934	0.672
	*	0.434	4 070	0.704	0.074
2	*	0.171	-1.078	-0.704	0.374
3	* *	0.223	-0.600	-0.355	0.245
3	*	0.223	0.000	0.500	0.270
4	*	0.276	-0.482	-0.279	0.203
•	*		•••		
5	*	0.328	-0.360	-0.207	0.154
	*				
6	*	0.380	-0.236	-0.137	0.099
_	*				
7	*	0.433	-0.169	-0.100	0.069
•	*	0.405	0.450	0.000	0.061
8	*	0.485	-0.152	-0.090	0.061
9	* *	0.537	-0.135	-0.081	0.054
-	*	0.001	0.100	0.001	0.004
10	*	0.589	-0.118	-0.072	0.046
• •	*				
11	*	0.668	0.085	0.055	-0.030
	*				
12	*	0.720	0.156	-0.022	-0.178
	*			A : A 4 A	
13	*	0.766	0.052	-0.046	-0.097
	* *				
****	*******	रजन के	******	x x x x x x x x x x x x x x x x x x x	**************

^{*} Change in pressure coefficient represents the difference between lower and upper surface pressure coefficients

ANGLE N			E	6		FLAP	DEFLECT	ION	ANGLE	2	5
*****	****	****	****	**;	******	****	******	***	****	***	:***
RESUL	rs of	SEAP	DATA	I	NTERPOLAT	ED TO) PHASE	I TE	AP LOC	ATIC)NS
*****	****	****		***	******	****		***		***	***
TAP NUMBER	* ? *	100	x/c atio	.	agu Sagu	, -	Cp lowe		chai	196 196	in
	•				9445 ******	•		•			***
1	*	6	.119		-1.77	7	-0.74	4	1.	.033	}
2	* *	6	3.171		-1.16	4	-0.58	9	0.	. 575	i
3	 ★ *	e	3 .2 23		-0.63	8	-0.29	5	0	. 343	ł
4	*	6	.276		-0.50	6	-0.23	3	0.	. 273)
5	* *	e	.328		-0.36	2	-0.18	2	ø.	. 180	l
6	* *	e	.380		-0.21	9	-0.13	9	0.	071	
7	*	e	.433		-0.12	3	-0.11	5	0.	012	•
8	* *	e	.485		-0.10	5	-0.11	2	-0.	006	
9	*	e	. 5 37		-0.08	4	-0.108	3	-0.	024	
10	*	e	.589		-0.06		-0.100	3	-0.	042	
11	*		.668		0.21	_	-0.056			261	
12	*	و	.720		0.319	9	-0.193	3	-0.	511	
13	*		.766		0.160		-0.154			314	
*****	****	****	***	***	****	****	****	***	****	***	***

^{*} Change in pressure coefficient represents the difference between lower and upper surface pressure coefficients

ANGLE OF ATTACK = 0 FLAP DEFLECTION ANGLE = 10 FILE NUMBER 56 ********** RESULTS OF SEAP DATA INTERPOLATED TO PHASE I TAP LOCATIONS **************** аĴ TAP Сp change in NUMBER * location upper lower GP. ************** 0.119 -1.977~0.695 1.282 2 -1.328 -0.515 0.812 0.1713 0.223 -0.856 -0.198 0.658 -0.690 4 0.276 -0.106 0.585 5 0.328 -0.595 -0.031 0.563 × 6 0.042 0.380 -0.503 0.545 0.078 0.433 -0.4640.542 -0.4550.093 0.548 8 0.485 9 0.537 -0.4470.108 0.555 0.589 -0.438 0.123 0.561 10 ¥ 11 0.668 -0.5110.328 0.839 12 0.720 -0.2940.188 0.482 13 0.766 -0.2640.177 0.441

^{*} Change in pressure coefficient represents the difference between lower and upper surface pressure coefficients

ANGLE OF ATTACK = 3 FLAP DEFLECTION ANGLE = 10 FILE NUMBER 57

****	***	**************	*****	*****	******
TAP	*	x/c	Cp	Cp	change in
NUMBER	*	location	upper	lower	Cp
*****	***	***************	******	***********	********
1	*	0.119	-2.555	-0.279	2.276
2	¥	0,:71	-1.697	-0.219	1.478
3	*	0.223	-1.104	-0.006	1.098
4	*	0.276	-0.893	0.054	0.947
5	* *	0.328	-0.762	0.102	0.864
6	* *	0.380	-0.635	0.149	0.783
7	* *	0.433	-0.579	0.172	0.751
8	*	0.485	-0.564	0.183	0.747
	*				
9	* *	0.537	-0.550	0.193	0.743
10	*	0.589	-0.535	0.203	0.739
11	* *	0.668	-0.558	0.370	0.928
12	*	0.720	-0.331	0.231	0.562
13	π **	0.766	-0.300	0.219	0.519
*****	≂ €÷÷∻	******	*****	*****	******

^{*} Change in pressure coefficient represents the difference between lower and upper surface pressure coefficients

ANGLE OF ATTACK = 6 FLAP DEFLECTION ANGLE = 10 FILE NUMBER 58

TAP NUMBER	*	x/c location	Cp upper	Cp low∉r	change in Co
1	:	0.119	-3.156	0.086	3.242
2	*	0.171	-2.070	0.050	2.119
3	* *	0.223	-1.359	0.175	1.533
4	*	0.276	-1.101	0.207	1.308
5	*	0.328	-0.932	0.230	1.162
6	 * *	0.380	-0.767	0.253	1.020
7	*	0.433	-0.693	0.266	0.959
8	* *	0.485	-0.672	0.272	0.944
9	* *	0.537	-0.651	0.278	0.929
10	 * *	0.589	-0.630	0.284	0.914
11	*	0.668	-0.601	0.413	1.014
12	*	0.720	-0.364	0.276	0.640
13	*	0.766	-0.332	0.263	0.595

^{*} Change in pressure coefficient represents the difference between lower and upper surface pressure coefficients

ANGLE OF			0	FLAP	DEFLECTION	ANGLE = 15
*****	****	******	******	*****	*****	******
RESUL:	rs of	SEAP DAT	A INTERPOL	ATED TO	PHASE I T	AP LOCATIONS

TAP	*	×/c	=	P A	Cp	change in
NUMBER	•	locati		P&!	lower	a) ********
1	*	0.11	9 -2.	411	-0.433	1.978
2	* *	0.17	1	526	-0.322	1.204
2	⊼ *	0.17	1 -1.	326	-0.322	1.204
3	×	0.22	3 -0.	902	0.011	0.914
4	*	0.27	€ -0.	858	0.034	0.892
5	*	0.32	s - 0.	814	0.056	0.870
-	*		•			
6	*	0.38	0 -0.	736	0.111	0.846
7	*	0.43	з -0.	609	0.220	0.829
8	*	0.48	5 -0.	611	0.230	0.841
9	*	0.53	7 -0.	613	0.240	0.8 5 3
	*			-		
10	* *	0.5 8	9 -0.	615	0.250	0.866
11	*	0.66	8 -0.	882	0.436	1.318
12	*	0.72	0 -0.	751	0.399	1.150
13	* *	0.76	6 -0.	250	0.240	0.490

^{*} Change in pressure coefficient represents the difference between lower and upper surface pressure coefficients

ANGLE OF ATTACK = 3 FLAP DEFLECTION ANGLE = 15 FILE NUMBER 60

*****	***	************	******	******	*******
TAP	*	x/c	අට	Ce	change in
NUMBER	*	location	upper	lower	Cp
*****	***	*******	*****	*****	********
1	*	0.119	-2.932	-0.077	2.855
	÷	A 474	4 000	0.067	1.016
2	*	0.171	-1.882	-0.067	1.816
3	*	0.223	-1.113	0.154	1.267
3	×	0.223	1.115	0.204	11201
4	*	0.276	-1.056	0.169	1.225
•	*				
5	÷	0.328	-1.001	0.183	1.183
	*				
6	*	0.380	-0.893	0.218	1.111
_	*	0.400	0.740	0.000	1 001
7	*	0.433	-0.710	8.2 9 8	1.001
8	* *	0.485	-0.708	0.298	1.006
۰	*	0.700	0.100	0.270	1.000
9	÷	0.537	-0.706	0.305	1.011
•	*	••••			
10	×	0.589	-0.704	0.312	1.016
	*				
11	*	0.668	-0.908	0.470	1.378
	*		. 955	0.400	4 455
12	*	0.720	-0.755	0.430	1.185
10	*	0.766	-0.260	0.266	0.527
13	*	0.766	-0.200	0.200	0.021
******	- ⊼ } 	· * * * * * * * * * * * * * * * * * * *	**********	*****	*****

^{*} Change in pressure coefficient represents the difference between lower and upper surface pressure coefficients

ANGLE OF ATTACK = 6 FLAP DEFLECTION ANGLE = 15 FILE NUMBER 61

• * * * * * * *	***	*******	*****	******	******
TAP	÷	x/c	Cp	aÛ	change in
NUMBER	*	location	upper	lower	CP.
****	***	*****	********	*****	********
1	*	0.119	-3.525	0.249	3.774
2	₹ *	0.171	-2.234	0.177	2.411
-	*	01111		V*1''	61711
3	*	0.223	-1.327	0.296	1.623
	*				
4	*	0.276	-1.234	მ.306	1.540
_	*				
5	* *	0.328	-1.140	0.317	1.457
6	*	0.380	-0.950	0.345	1.295
. •	*	0.300	0.700	0.970	1.670
7	*	0.433	-0.817	0.366	1.182
	*				
8	*	0.485	-0.809	0.371	1.180
_	*				
9	*	0.537	-0.802	0.375	1.177
10	*	0.589	-0.795	0.380	1.175
	*	3.33			
11	*	0.668	-0.947	0.511	1.459
	*				
12	*	0.720	-0.775	0.471	1.246
10	*	0.766	-0.272	0.302	0.574
13	*	0.766	-0.272	0.302	0.574
****	~ ***	*****	*****	*********	******

^{*} Change in pressure coefficient represents the difference between lower and upper surface pressure coefficients

ANGLE O		ACK = 62	9	FLAP	DEFLECTI	ON ANGLE	= 10
*****	****	******	******	****	******	*****	*****
RESULT	S OF	SEAP DATE	A INTERPOLA	TED TO) PHASE I	TAP LOCA	ATIONS
	****		**************************	*****	:****** Cp		
TAP NUMBER	••	x/c locatio	• •	er	lower		nse in Op
******	*****	0.119	9 -3.7		0.395		155
2	*	0.171	-2.4	26	0.284	2.	709
3	* * *	0.223	-1.6	16	0.339	1.	954
4	*	0.276	-1.3	12	0.349	1.	661
5	* *	0.328	-1.10	3 8	0.353	1.	461
6	*	0.380	-0.90	9 6	0.357	1.	264
7	* *	0.433	-0.8	16	0.361	1.	176
8	*	0.485	-0.78	39	0.363	1.	152
9	*	0.537	' -0.76	52	0.366	1.	128
10	* *	0.589	-0.70	35	0.369	1.	104
11	*	0.668	-0.67	75	0.467	1.	141
12	*	0.720	-0.39	98	0.330	ଡ.	728
13	*	0.766	-0.36	55	0.317	0.	681

^{*} Change in pressure coefficient represents the difference between lower and upper surface pressure coefficients

ANGLE OF ATTACK = 9 FLAP DEFLECTION AMGLE = 15 FILE NUMBER 63

*****	****	******	********	*******	******
TAP	*	x/c	Сp	φĴ	change in
NUMBE	R *	location	upper	lower	Ce
****	****	**************	******	******	*****
1	*	0.119	-4.130	0.518	4.648
	*				
2	*	0.171	-2.590	0.388	2.978
	*				
3	*	0.223	-1.528	0.424	1.953
	*				
4	÷	0.276	-1.448	0.425	1.873
_	*				
5	X	0.328	-1.369	0.426	1.795
_	*				4 455
6	*	0.380	-1.204	0.430	1.635
_	*	0.400	0.000	0.440	4 040
7	*	0.433	-0.909	0.440	1.349
	*	0.405	a 000	0.440	4 044
8	*	0.485	-0.898	0.443	1.341
	*	0 503	.0.00	0.446	1.334
9	*	0.537	-0.888	0.440	1.334
10	* *	0.589	-0.878	0.449	1.327
16	*	v. Joa	-0.010	U. 772	1.321
11	*	0.668	-0.998	0.568	1.566
* *	*	0.000	0.220	0.000	1.000
12	÷	0.720	-0.801	0.522	1.323
• -	 *	0.120	~.~~		
13	*	0.766	-0.283	0.346	0.629
	*	*****			
*****	****			***********	*****

^{*} Change in pressure coefficient represents the difference between lower and upper surface pressure coefficients

ANGLE FILE N			9	FL	AP DEFLECTI	ON ANGLE = 5
*****	****	******	***	*****	*****	******
RESUL	TS OF	SEAP DAT	A IN	TERPOLATED	TO PHASE I	TAP LOCATIONS
			***			*****
TAP NUMBE	* R *	x/c locati	on	q) reqqu	Cp lower	change in Cp

1	*	0.11	9	-1.980	-0.509	1.471
2	* * *	0.17	1	-1.270	-0.435	0.835
3	*	0.22	3	-0.698	-0.197	0.501
4	* * *	0.27	6	-0.551	-0.149	0.402
5	*	0.32	8	-0.385	-0.120	0.266
6	* *	0.38	Ø	-0.208	-0.100	0.108
7	*	0.43	3	-0.112	-0.090	0.022
8	*	0.48	5	-0.086	-0.088	-0.002
9	×	0.5 3	7	-0.060	-0.086	~0.026
10	*	0.58°	9	-0.034	-0.084	-0.050
11	* *	0.66	3	0.271	-0.027	-0.298
12	*	0.72	3	0.482	-0.472	-0.954
13	* *	0.76	5	0.265	-0.303	-0. 5 68
	.~					

^{*} Change in pressure coefficient represents the difference between lower and upper surface pressure coefficients

```
0: "SEAP INTERPOL. PROG.":
1: dim X[13],U[13],U[13],C[13],A;D;dim G[23],H[23],U[23],O;Q
2: dim E[13,16],R[16],D[16];dim B[4,4],P;X
3: .119+X[1];.171+X[2];.223+X[3];.276+X[4];.328+X[5];.38+X[6];.433+X[7]
4: .485+X[8];.527+X[9];.589+X[10];.668+X[11];.72+X[12];.766+X[13]
5: trk lifor F=34 to 48
6: ldf f;G[*],H[*],J[*],O;Q
7: for I=1 to 13
8: for J=1 to 22
9: if X[I]#G[J];*to 11
10: H[J]+U[I];[[J]+L[I]]*to 15
11: if not (X[I])G[J] and X[I](G[J+1]);*to 16
12: (X[I]-G[J])/(G[J+1]-G[J])+Z
13: Z(H[J+1]-H[J])+H[J]+U[I]
14: Z([[J+1]-H[J])+H[J]+U[I]
15: L[I]-U[I]+C[I]+E[I,F-33]
16: next J
17: next I
18: O+A[F-33]+A;Q+D[F-33]+D
19: rcf F+16;X[*];U[*];L[*];C[*];A;D
20: next F
21: for T=1 to 13;T+P;X[T]+X
22: for S=1 to 16
23: E[T-S]+B[D[S]/5+1;A[S]/3+1]
24: next S
25: fdf T+65;rcf T+65;B[*],P;X
26: next T
*24010
```

OMOUNAL PACE IS OF PUR QUALITY

```
0: "SEAP - DELTA C SUB P OUTPUTTING PROGRAM files 50+65": 1: dim LS[80].PS[3].YS[80].SS[10]);for S=1 to 60; "+"+LS[S];next Sifxd 1
                                                                    "&L$+L$
2: din X[13];U[13];L[13];C[13];A;D;"
3: "+$$
4: fmt 1:10x:f3.0:4x; "*":4f12.3
5: fmt 2:9x; "ANGLE OF ATTACK = ":f4.0:10x:"FLAP DEFLECTION ANGLE = ":f4.0
6: fmt 3:9x:"FILE NUMBER ":f2.0
7: "PCL":ent "FILE NUMBER?":Fiif F>65 or F<50:*to +0
St trk lifdf Fildf F.X[*].U[*].L[*].C[*].A.D
                                             9: "STR": wrt 6: 10: wrt 6: "
                                             KANSAS UNIVERSITY FLIGHT RESEARCH LAB JUFE 6
DELTA P PROJECT - PHASE I"
11: wrt 6:"
12: wrt 6
                                             SINGLE ELEMENT AIRFOIL PROGRAM RESULTS"
13: urt 6,"
14: wrt 6jurt 6jurt 6jurt 6.2, A. Djurt 6.3, Fjurt 6jurt 6, Lijurt 6
15: wrt 6, Sit "RESULTS OF SEAP DATA INTERPOLATED TO PHASE I TAP LOCATIONS"
16: wrt 6; wrt 6, L$
17: wrt 6, S$$ TAP
                                                               Cp
                                                                                 Сp
                                                                                               change in"
                                             X/C
18: wrt 6:S#&"NUMBER *
                                        location
                                                              upper
                                                                                lower
19: wrt 6.L$
20: for $=1 to 13
21: wrt 6.1:5:XES1:UES1:EES1:CES1:wrt 6:"
                                                                                        *"Inext S
22: urt 6:L#iurt 6iurt 6iurt 6
23: wrt 6,55% Change in pressure coefficient represents the difference"
24: wrt 6,55% between lower and upper surface pressure coefficients"
25: for S=1 to 12; wrt 6; next S
26: ent "another file?":P$lif cap(P$)#"N"lato "PCL"
27: SEP
*13077
```

C.4 INTERPOLATED CHANGE IN C P BY TAP LOCATION

TAP NUMBER 1
TAP x/c LOCATION 0.119

FILE NUMBER 66

FLAP FLECTIO	* N*	ALPHA: 0	-ANGLE OF ATTAI 3	CK (dearees) 6	9
*****	******	***************			******
0.0	*	0.999	0.854	1.764	0.000
5.0	*	0.352	0.672	1.033	1.471
10.0	*	1.282	2.276	3.242	4.155
15.0	* *	1.978	2.855	3.774	4.648

- * Results of SEAP data interpolated to phase I tap lacations
- Change in pressure coefficient represents the difference between lower and upper surface pressure coefficients

TAP NUMBER 2

FILE NUMBER 67

TAP x/c LOCATION 0.171

ECTION*	0	3	6	9
********	******	**********	**********	**********
0.0 ÷	0.000	0.587	1.177	0.000
5.0 *	0.165	0.374	0.575	0.835
10.0 *	0.812	1.478	2.119	2.709
15.0 *	1.204	1.816	2.411	2 .9 78

- st Results of SEAP data interpolated to phase I tap lacations
- * Change in pressure coefficient represents the difference between lower and upper surface pressure coefficients

TAP NUMBER 3

FILE NUMBER 68

ECTIO	N*	0	3	6	9
****	*****	*****	****	*****	******
0.0	*	0.000	0.431	0.866	0.000
5.0	*	0.156	0.245	0.343	0.501
10.0	*	0.658	1.098	1.533	1.954
15.0	*	0.914	1.267	1.623	1.953

- Results of SEAP data interpolated to phase I tap lacations
- Change in pressure coefficient represents the difference between lower and upper surface pressure coefficients

TAP NUMBER 4

FILE NUMBER 69

TAP x/c LOCATION 0.276

CHANGE IN PRESSURE COEFFICIENT INTERPOLATED

FLAP * LECTION*	a	-ANGLE OF ATTAI	£	a
******		******	*******	**********
*				
0.0 *	0.000	0.273	0.561	0.000
*				
5.0 *	0.147	0.203	0.273	0.402
10.0 *	0.585	0.947	1.308	1.661
**	0.303	0.271	1.300	1.001
15.0 *	0.892	1.225	1.540	1.873

- * Results of SEAP data interpolated to phase I tap lacations
- * Change in pressure coefficient represents the difference between lower and upper surface pressure coefficients

TAP NUMBER 5

FILE NUMBER 70

FLAP * LECTION*	Ø	-ANGLE OF ATTA 3	6	9
	******	*******	*******	******
0.0 *	0.000	0.255	0.527	0.000
5.0	0.142	0.154	0.180	0.266
10.0 *	0.563	0.864	1.162	1.461
15.0 *	0.870	1.183	1.457	1.795

- * Results of SEAP data interpolated to phase I tap locations
- Change in pressure coefficient represents the difference between lower and upper surface pressure coefficients

TAP NUMBER 6

FILE NUMBER 71

TAP x/c LOCATION 0.380

FLAP * FLECTION*	ALPHA: 0	-ANGLE OF ATTA 3	CK (degrees) 6	9
******	********	********	***********	*********
0.0 *	0.996	0.237	0.493	0.000
5.0 *	0.139	0.099	0.071	0.108
10.0 *	0.545	0.783	1.020	1.264
15.0 *	0.846	1.111	1.295	1.635

- * Results of SEAP data interpolated to phase I tap locations
- Change in pressure coefficient represents the difference between lower and upper surface pressure coefficients

TAP NUMBER 7

FILE NUMBER 72

TAP X/c LOCATION 0.433

FLAP *		_	UNCTE OŁ ULLUCK (Gealees)		_
FLECTIO		0	j ************	5	y
*****	********************	*******	****	* * * * * * * * * * * * * * * * * * *	*****
9.9	* *	0.000	0.145	0.316	0.000
5.0	*	0.140	0.069	0.012	0.022
10.0	* *	0.542	0.751	0.959	1.176
15.0	* *	0.829	1.001	1.182	1.349
	×	2.24.			

- Results of SEAP data interpolated to phase I tap lacations
- Change in pressure coefficient represents the difference between lower and upper surface pressure coefficients

TAP NUMBER 8

FILE NUMBER 73

TAP x/c LOCATION 0.485

FLAP LECTIO	* N*	0	-ANGLE OF ATTA 3	6	9
*****	*****	********	*******	*******	******
0.0	*	0.000	0.127	0.273	0.000
5.0	* *	0.142	0.061	-0.006	-0.002
10.0	*	0.548	0.747	0.944	1.152
15.0	* *	0.841	1.006	1.180	1.341

st Results of SEAP data interpolated to phase I tap lacations

^{*} Change in pressure coefficient represents the difference between lower and upper surface pressure coefficients

TAP NUMBER 9

FILE NUMBER 74

TAP x/c LOCATION 0.537

ECTION*	;	a	-ANGLE OF ATTA 3	6	9
**************************************	*****	******	*******	********	******
0.0 *	•	0.000	0.124	0.265	0.000
5.0 *		0.144	0.054	-0.024	-0.026
10.0 *		0.555	0.743	0.929	1.128
15.0 *		0.853	1.011	1.177	1.334

st Results of SEAP data interpolated to phase I tap lacations

Change in pressure coefficient represents the difference between lower and upper surface pressure coefficients

TAP NUMBER 10

FILE NUMBER 75

TAP x/c LOGATION 0.589

ECTION	*	0	-ANGLE OF ATTA 3	6	9
**************************************		*********	********	*********	*******
	~ * *	0.000	0.120	0.257	0.000
	* * *	0.147	0.046	-0.042	-0.050
10.0	* * *	0.561	0.739	0.914	1.104
15.0	* * 	0.866	1.016	1.175	1.327

- * Results of SEAP data interpolated to phase I tap lacations
- * Change in pressure coefficient represents the difference between lower and upper surface pressure coefficients

TAP NUMBER 11

FILE NUMBER 76

TAP x/c LOCATION 0.668

FLAP FLECTIO	* *N	0	-ANGLE OF ATTA 3	6	9
*****	******	********	******	**********	******
0.0	*	0.000	0.115	0.245	ଡ.ଡଚ୍ଚ
5.0	*	0.226	-0.030	-0.261	-0.298
10.0	*	0.839	0.928	1.014	1.141
15.0	*	1.318	1.378	1.459	1.566

- * Results of SEAP data interpolated to phase I tap lacations
- Change in pressure coefficient represents the difference between lower and upper surface pressure coefficients

KANSAS UNIVERSITY FLIGHT RESEARCH LAB DELTA P PROJECT - PHASE I SINGLE ELEMENT AIRFOIL PROGRAM RESULTS

TAP NUMBER 12

FILE NUMBER 77

TAP x/c LOCATION 0.720

CHANGE IN PRESSURE COEFFICIENT INTERPOLATED

LECTIO	ikl z	0	N-ANGLE OF ATTA		٩
- LEC 10	INT XXXXXXX	-	. * * * * * * * * * * * * * * * * * * *		
*****	талалала X	* * * * * * * * * * * * * * * * * * *	******	*******	******
0.0	÷	0.000	0.084	0.180	0.000
	*				
5.0	*	0.107	-0.178	-0.511	-0.954
	*				
10.0	X	0.482	0.562	0.640	0.728
	*				
15.0	*	1.150	1.185	1.246	1.323
	*				

- * Results of SEAP data interpolated to phase I tap lacations
- * Change in pressure coefficient represents the difference between lower and upper surface pressure coefficients

KANSAS UNIVERSITY FLIGHT RESEARCH LAB DELTA P PROJECT - PHASE I SINGLE ELEMENT AIRFOIL PROGRAM RESULTS

TAP NUMBER 13

FILE NUMBER 78

TAP x/c LOCATION 0.766

CHANGE IN PRESSURE COEFFICIENT INTERPOLATED

FLAP * LECTION*	0	A-ANGLE OF ATTA 3	F CONTRACTOR	9
*****		******	******	******
*				
0.0 *	0.000	0.082	0.174	0.000
* 5.0 *	0.094	-0.097	-0.314	-0.568
*	0.077	0.021	0.017	-0.000
10.0 *	0.441	0.519	0.595	0.681
*				
15.0 *	0.490	0.527	0.574	0.629

- Results of SEAP data interpolated to phase 1 tap lacations
- * Change in pressure coefficient represents the difference between lower and upper surface pressure coefficients

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KANSAS UNIVERSITY FLIGHT RESEARCH LAB": WF & 6 DELTA P PROJECT - PHASE I"
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 11: wrt 6
11: UPL 6
12: UPL 6:T$&"

SINGLE ELEMENT AIRFOIL PROGRAM PESULTS"
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17: Wrt 6: Wrt 6, SEL $
18: Wrt 6, FLAP #
19: Wrt 6, DEFLECTION + ", Y$
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20: urt 6:5#&L#iwrt 6:T#&"
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 21: for I=1 to 4; (I-1)5+C; urt 6.4; C; for J=1 to 4
22: urt 6.3:B[l:J]inext Jiurt 6iurt 6:T$&"
23: next I
 24: wrt 6:5$&L$lurt 6lurt 6lurt 6lurt 6lurt 6lurt 6
25: wrt 6:7$% * Results of SEAP data interpolated to phase I tap lacations"
26: wrt 6
 27: wrt 6:T$&"+
                                                          Change in pressure coefficient represents the difference"
28: wrt 6, T#4"
                                                     between lower and upper surface pressure coefficients'
29: for 3=1 to 16
38: wrt 6inext Sient "ANOTHER FILE?", P$i if cap(P$)="Y"jeto "PCL"
31: end
*8226
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C.5 GRAPHICAL OUTPUT--FLAP DEFLECTION SENSITIVITY

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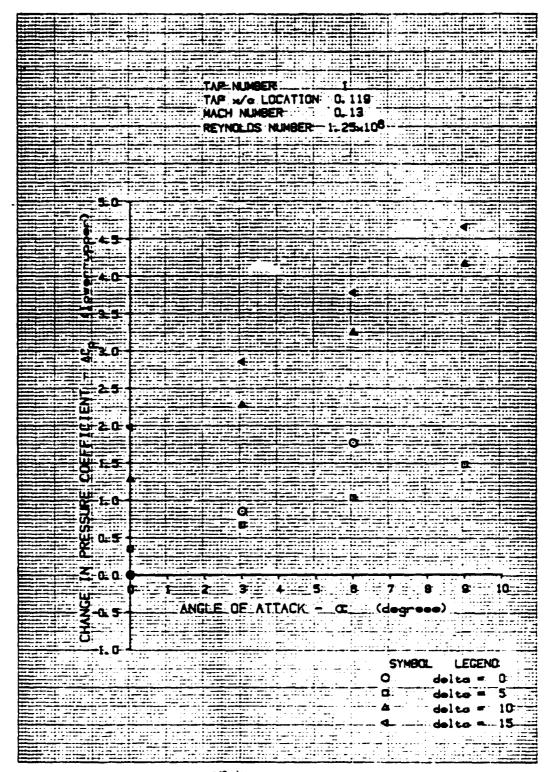
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C.6 GRAPHICAL OUTPUT--ANGLE OF ATTACK SENSITIVITY



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11 12 12 12 12 12 12 12 12 12 12 12 12 1					dagrees2 SYMBOL L Commonwealth	G- EGENO:
11 12 12 12 12 12 12 12 12 12 12 12 12 1					dagrees2 SYMBOL L Commonwealth	GF GF EGEND:
11 12 12 12 12 12 12 12 12 12 12 12 12 1				0 3 3 - G (	SYMBOL L	GECENO:
11 12 12 12 12 12 12 12 12 12 12 12 12 1				0 3 3 - G (	dagreee) SYMBOL L O delt G delt	EGENO: = 0: = 5: = 10:
11 12 12 12 12 12 12 12 12 12 12 12 12 1				6 2 4 4 (	dagreee) SYMBOL L O delt G delt	EGENO: = 0: = 5: = 10:
33 1.5 33 1.5 33 6.5 34 8.3 35 6.5				6 2 4 4 (	dagreee) SYMBOL L O delt G delt	GECENCE
33 1.5 33 1.5 33 6.5 34 8.3 35 6.5				6 2 4 4 (	dagreee) SYMBOL L O delt G delt	EGENO: = 0: = 5:
11 1 1 5 1 5 1 5 1 5 1 5 1 5 1 5 1 5 1				6 2 4 4 (	dagreee) SYMBOL L O delt G delt	ECENO:  = 0: = 5: = 10:
11 1 1 5 1 5 1 5 1 5 1 5 1 5 1 5 1 5 1				6 2 4 4 (	dagreee) SYMBOL L O delt G delt	ECENO:  = 0: = 5: = 10:
14 20 25 3 3 4 5 4 5 4 5 4 5 4 5 5 4 5 5 5 5 5				6 2 4 4 (	dagreee) SYMBOL L O delt G delt	EGENO: = 0: = 5:

CALC	P. FINN	861	AEVISED	DATE	FIGURE C. 26 SEAP THEORETICAL CHANGE	DATE
CHECK	RHAABAK	8-81			IN PRESSURE COEFFICIENTS	5-0-01
APPO					<u>- ANGLE OF ATTACK</u> SENSITIVITY	
APPO						PAGE 172
					UNIVERSITY OF KANSAS	172

## C.7 NUMERICAL REGRESSION DATA

### DELTA P PROJECT SEAP

#### RESULTS OF LINEAR CURVE FITTING

FILE NUMBER 66

TAP NUMBER 1

DELTA (flap deflection angle) versus CHANGE IN PRESSURE COEFFICIENT AT DIFFERENT ANGLES ANGLES OF ATTACK (alpha)

ককক ভ	रिक्तिक	ति ते ति है। ज	****	কিক্তিক ভ	********	কিক: স	****	**
*		*		*		*		*
* a	ipha	*	SLOPE	*	INTERCEPT	*	COEFFICIENT OF	÷
*		*		*		*	DETERMINATION	*
*		*		*		*		*
***	***	***	*****	<del>***</del>	*****	**:	*******	**
*		*		*		*		*
*	0	*	0.137	*	-0.127	*	0.97	*
*	3	*	0.152	*	0.523	*	0.84	×
*	6	*	0.165	*	1.218	*	0.70	×
*	9	*	0.318	÷	0.247	*	0.86	*
×.		×		*		*		×

<del>*</del> •	t + # # # # #	***	*****	***	****	**	************	***
*		*		*		*		*
*	delta	*	SLOPE	*	INTERCEPT	+	COEFFICIENT OF	F *
*		*		*		*	DETERMINATION	*
*		×		*		*		*
* 4	*****	***	*******	***	*****	**	******	***
*		*		*		*		*
*	Ø	*	0.294	*	-0.009	*	1.00	*
*	5	*	0.124	*	0.324	*	0.99	*
÷	10	*	0.319	*	1.301	*	1.00	*
*	15	÷	0.298	*	1.974	*	1.00	*
*		*		*		*		*
+-	*****	÷	******	***	******	++-	******	+++

#### DELTA P PROJECT SEAP

#### RESULTS OF LINEAR CURVE FITTING

FILE NUMBER 67

TAP NUMBER 2

DELTA (flap deflection angle) versus CHANGE IN PRESSURE COEFFICIENT AT DIFFERENT ANGLES ANGLES OF ATTACK (alpha)

*		¥		÷		×		
* a	1pha	*	SLOPE	*	INTERCEPT	*	COEFFICIENT (	OF ·
•		*		×		¥	DETERMINATION	N 4
÷		*		×		×		
<del>(**</del>	****	***	<del>******</del>	***	*****	**	*********	***
٠		*		*		*		4
÷	0	×	0.085	*	-0.094	¥	0.96	+
÷	3	×	0.096	¥	0.346	*	0.30	+
	6	*	0.105	*	0.784	÷	0.64	+
<del>!</del>	9	×	0.214	*	0.031	*	0.84	÷
<b>-</b>		¥		¥		×		÷

**	****	<del>* * *</del>	*****	***	*****	****	******	****
*		×		*		*		*
* (	delta	*	SLOPE	*	INTERCEP'	T * 1	COEFFICIENT	0F *
*		¥		*		*	DETERMINATI	ON *
*		¥		*		¥		*
**	****	<del>*</del> *	******	***	*****	***	******	****
*		*		¥		¥		×
*	0	*	0.196	×	-0.000	*	1.00	*
*	5	¥	0.074	*	0.155	*	1.00	*
*	10	*	0.211	*	0.830	÷	1.00	*
*	15	×	0.197	×	1.215	*	1.00	*
*		×		*		*		*
**	****	**	******	***	*****	***	*****	****

### DELTA P PROJECT SEAP

### RESULTS OF LINEAR CURVE FITTING

FILE NUMBER 68

TAP NUMBER 3

DELTA (flap deflection angle) versus CHANGE IN PRESSURE COEFFICIENT AT DIFFERENT ANGLES ANGLES OF ATTACK (alpha)

*		*		*		*		÷
* a	lpha	*	SLOPE	×	INTERCEPT	×	COEFFICIENT OF	*
*		*		*		*	DETERMINATION	¥
<del>X</del>		*		*		×		*
**+	****	***	******	***	******	÷÷:	******	**
*		*		*		×		×
*	0	*	0.065	*	-0.054	*	0.96	÷
÷	3	*	0.067	*	0.256	×	0.76	*
<del>*</del>	6	*	0.069	*	0.572	*	0.55	¥
*	9	*	0.145	*	0.018	*	0.75	÷
*		¥		*		*		×

÷		*		*		*	
ن ۱	ielta	*	SLOPE	*	INTERCEPT	*	COEFFICIENT OF
•		*		÷		*	DETERMINATION
•		*		×		*	
+ +	****	***	******	***	******	**	*****
		*		*		*	
	0	*	0.144	*	-0.001	*	1.00
	5	*	0.038	*	0.141	*	0.98
	10	*	0.144	*	0.662	*	1.00
	15	*	0.116	*	0.918	*	1.00
		*	_	*		¥	_

#### DELTA P PROJECT SEAP

#### RESULTS OF LINEAR CURVE FITTING

### FILE NUMBER 69

#### TAP NUMBER 4

DELTA (flap deflection angle) versus CHANGE IN PRESSURE COEFFICIENT AT DIFFERENT ANGLES ANGLES OF ATTACK (alpha)

**	*****	<del>* * 3</del>	******	**	******	* *	******	**
*		*		*		*		×
*	alpha	*	SLOPE	*	INTERCEPT	*	COEFFICIENT OF	*
*		¥		*		¥	DETERMINATION	*
*		¥		*		*		×
**	****	***	******	***	*****	* *	*****	÷ ÷
*		*		*		*		*
*	0	×	0.062	*	-0.061	×	0.97	*
*	3	*	0.072	*	0.122	*	0.85	*
*	6	×	0.079	×	0.325	×	0.73	*
*	9	×	0.147	*	-0.159	*	0.86	×
*		¥		*		☀		×
¥÷	****	**	******	***	*****	**	*****	÷÷

<b>· *******************</b>								
*		*		*		*		٠
* (	delta	*	SLOPE	*	INTERCEPT		COEFFICIENT OF	*
*		¥		*		*	DETERMINATION	÷
*		*		×		*		*
*************								
*		*		*		*		*
*	0	¥	0.094	*	-0.003	*	1.00	*
*	5	¥	0.928	*	0.131	*	0.96	*
*	10	*	0.120	*	0.587	*	1.00	*
+	15	*	0.109	*	0.893	*	1.00	*
*		*		*		٠		*
**************								

## DELTA P PROJECT SEAP

## RESULTS OF LINEAR CURVE FITTING

FILE NUMBER 70

TAP NUMBER 5

DELTA (flap deflection angle) versus CHANGE IN PRESSURE COEFFICIENT AT DIFFERENT ANGLES ANGLES OF ATTACK (alpha)

***	****	***	*****	***	******	**	*****	* *
*		*		*		*		*
* 0	ilpha	×	SLOPE	*	INTERCEPT	*	COEFFICIENT OF	*
*		*		*		¥	DETERMINATION	*
*		*		*		×		÷
***	****	***	******	***	*******	**	*****	* *
*		¥		*		×		*
*	0	*	0.061	*	-0.061	×	0.97	*
÷	3	*	0.070	×	0.090	×	0.84	×
*	6	*	0.075	×	9.266	*	0.70	*
*	9	*	0.153	*	-0.356	*	0.90	¥
*		*		*		*		*
***	****	***	******	***	*******	¥ ¥·	***********	¥ ¥

* * * * *	delta	***	SLOPE	*	INTERCEPT		COEFFICIENT OF DETERMINATION	* * *
*	*****	***	******	***	******	**	*****	* *
*	0	*	0.088	*	-0.003	*	1.00	*
*	5	*	0.013	*	0.125	*	0.84	*
*	10	*	0.100	*	0.564	*	1.00	*
*	15	*	0.102	*	0.869	*	1.00	*
٠		*	-	*		*		*
+ 4			******	***	******		*****	. 🛨

### DELTA P PROJECT SEAP

### RESULTS OF LINEAR CURVE FITTING

FILE NUMBER 71

TAP NUMBER 6

DELTA (flap deflection angle) versus CHANGE IN PRESSURE COEFFICIENT AT DIFFERENT ANGLES ANGLES OF ATTACK (alpha)

* 1	*****	***	******	**	<del>********</del>	* * :	******	<del>* *</del>
*		*		*		÷		÷
*	alpha	÷	SLOPE	*	INTERCEPT	*	COEFFICIENT OF	*
*		*		*		×	DETERMINATION	×
*		*		*		¥		*
* 3	*****	<del>* * *</del>	******	**	*******	÷ ÷	*****	**
*		*		*		*		×
÷	Ø	*	0.059	*	-0.059	÷	0.97	*
*	3	×	0.066	*	0.051	×	0.82	*
×	6	¥	0.067	*	0.216	÷	0.63	*
*	9	×	0.153	×	-0.525	*	0.92	×
*		¥		*		×		*
**	*****	<del>: * *</del>	******	***	*******	<del>: * :</del> :	*******	**

* +	<del>6***</del> **	* * *	*****	***	******	**	<del>************</del>	***
÷		÷		*		<b>3</b> .		*
÷	delta	×	SLOPE	*	INTERCEPT	*	COEFFICIENT O	F
×		×		*		*	DETERMINATION	*
÷		×		*		÷		*
* 4	<del>*****</del>	<del>( * ;</del>	<del>{*********</del>	***	*****	**;	******	***
÷		×		<del></del>		÷		*
*	0	×	0.082	*	-0.003	*	1.00	*
*	5	×	-0.004	*	0.122	*	0.31	*
*	10	*	0.080	*	0.544	*	1.00	*
*	15	÷	0.085	*	0.840	*	0.99	÷
*		¥		*		*		*
* *	*****	<del>: * 4</del>	*******	***	******	<del>*</del>	<del>6***********</del>	***

## DELTA P PROJECT SEAP

## RESULTS OF LINEAR CURVE FITTING

FILE NUMBER 72

TAP NUMBER 7

DELTA (flap deflection angle) versus CHANGE IN PRESSURE COEFFICIENT AT DIFFERENT ANGLES ANGLES OF ATTACK (alpha)

*		*		*		*		¥
* a	lpha	*	SLOPE	÷	INTERCEPT	×	COEFFICIENT OF	×
<del>*</del>		*		*		¥	DETERMINATION	×
*		¥		*		×		*
<del>* * *</del>	****	***	*****	***	*****	* *	<del>* * * * * * * * * * * * * * *</del>	**
*		*		*		*		*
<del>X</del>	0	÷	0.058	*	-0.056	×	0.97	*
*	3	×	0.065	*	0.004	×	0.84	×
*	6	*	0.071	*	0.085	×	0.70	÷
*	9	÷	0.133	*	-0.478	×	0.85	×
*		×		*		*		×

* :	*****	***	*****	***	******	**	<del>************</del>	***
*		*		*		*		*
*	delta	*	SLOPE	*	INTERCEPT	*	COEFFICIENT OF	F *
×		÷		*		*	DETERMINATION	*
*		*		*		*		*
* :	*****	***	******	***	******	<del>* * :</del>	******	***
*		×		*		*		*
*	Ø	*	0.053	*	-0.004	*	1.00	*
×	5	*	-0.014	*	0.122	×	0.83	*
*	10	*	0.070	*	0.540	*	1.00	*
÷	15	*	0 <b>.05</b> 8	*	b.829	*	1.00	*
×		*		*		÷		*
* 4	*****	* * *	*****	***	******	* * 3	<del>*************</del>	* * *

### DELTA P PROJECT SEAP

### RESULTS OF LINEAR CURVE FITTING

FILE NUMBER 73

TAP NUMBER 8

DELTA (flap deflection angle) versus CHANGE IN PRESSURE COEFFICIENT AT DIFFERENT ANGLES ANGLES OF ATTACK (alpha)

*	*****	<del>* * :</del>	******	**	******	**	******	**
*		×		*		¥		*
*	alpha	*	SLOPE	×	INTERCEPT	*	COEFFICIENT OF	*
*		÷		*		*	DETERMINATION	*
*		*		×		*		÷
* :	*****	<del>( * :</del>	******	**	******	**	******	**
*		×		×		×		×
*	0	*	0.059	×	-0.057	×	0.97	×
*	3	*	0.066	*	-0.013	*	0.85	*
÷	6	*	0.073	÷	0.047	÷	0.73	*
*	9	*	0.134	*	-0.513	×	0.85	*
*		×		*		*		*
* 4	*****	+ + +	<del>********</del>	* * :	******	**:	******	**

* +	****	***	*****	***	******	****	***********	<del>*</del> * * * *
*		*		*		*		*
*	delto	<b>.</b> *	SLOPE	¥	INTERCEP	T * C	OEFFICIENT (	OF *
*		*		*		* D	ETERMINATIO	₩ *
*		*		*		*		*
* 3	****	***	*****	****	*****	****	*****	***
*		*		*		÷		*
¥	Ø	*	0.046	*	-0.093	*	1.00	*
*	5	*	-0.017	*	0.124	*	0.86	*
*	10	*	0.067	*	0.547	*	1.00	÷
*	15	*	0.056	*	0.841	*	1.00	*
*		*		*		*		÷
* *	****	***	*****	****	*****	****	******	****

### DELTA P PROJECT SEAP

## RESULTS OF LINEAR CURVE FITTING

FILE NUMBER 74

TAP NUMBER 9

DELTA (flap deflection angle) versus CHANGE IN PRESSURE COEFFICIENT AT DIFFERENT ANGLES ANGLES OF ATTACK (alpha)

***	****	***	*******	***	******	**	*******	**
*		*		*		*		*
* o	ilpha	*	SLOPE	×	INTERCEPT	*	COEFFICIENT OF	÷
*		¥		*		*	DETERMINATION	×
*		÷		*		*		÷
***	****	***	******	***	******	**;	<del>**************</del>	**
×		¥		*		*		*
*	Ø	÷	0.059	*	-0.057	*	0.97	*
*	3	*	0.067	*	-0.020	*	0.85	*
*	6	*	0.074	÷	0.034	×	0.72	*
*	9	÷	0.136	×	-0.548	÷	0.86	*
*		×		*		*		×
***	***	***	******	***	******	***	<del>************</del>	**

*	*****	**	******	***	******	**	******	***
*		*		*		*		*
*	delta	×	SLOPE	*	INTERCEPT	*	COEFFICIENT OF	= *
*		×		*		*	DETERMINATION	*
*		*		*		*		*
* :	*****	* * :	<del>(****</del> ****	***	******	**	******	<u> </u>
÷		¥		*		÷		*
*	0	¥	0.044	*	-0.003	*	1.00	*
*	5	×	-0.020	*	0.125	*	0.89	*
*	10	*	0.064	*	0.553	×	1.00	*
*	15	*	ย. 654	*	0.853	*	1.00	*
*		*		*		*		*
* 3	*****	÷ <del>*</del> ÷	*******	***	*******	**	<del>*************</del>	**

## DELTA P PROJECT SEAP

### RESULTS OF LINEAR CURVE FITTING

FILE NUMBER 75 TAP NUMBER 10

DELTA (flap deflection angle) versus CHANGE IN PRESSURE COEFFICIENT AT DIFFERENT ANGLES ANGLES OF ATTACK (alpha)

* 3	****	***	*****	****	******	***	******	****
*		*		×		÷		*
×	alpho	( *	SLOPE	*	INTERCEPT	*	COEFFICIENT :	OF *
÷		*		*		÷	DETERMINATION	N *
*		×		×		*		*
* *	****	***	******	***	******	**	<del>******</del>	****
*		*		*		*		÷
*	Ø	×	0.060	×	-0.058	*	0.97	*
×	3	*	0.068	*	-0.027	*	0.85	*
*	6	*	0.074	<del>X</del>	0.020	*	0.72	*
*	9	*	0.138	÷	-0. <b>5</b> 83	*	0.87	*
*		*		*		×		*
**	****	***	*******	<del>* * *</del>	******	***	<del>************</del>	****

*:	*****	**:	<del>********</del>	<del>***</del>	*******	**	*****	++
÷		÷		*		÷		*
*	delta	*	SLOPE	÷	INTERCEPT	*	COEFFICIENT OF	*
×		×		*			DETERMINATION	*
*		*		*		÷		*
* :	*****	<del>(                                    </del>	*******	***	********	* * :	*****	* *
*		×		×		*		*
*	0	*	0.043	*	-0.003	×	1.00	¥
÷	5	×	-0.023	*	0.127	×	0.91	÷
*	10	*	9.969	*	0.559	*	1.00	*
÷	15	*	0.051	*	0.865	*	1.00	*
*		*		*		*		*
* 3	*****	+++	*****	***	*****	+ + +	*****	<del>( *</del>

## DELTA P PROJECT SEAP

## RESULTS OF LINEAR CURVE FITTING

FILE NUMBER 76

TAP NUMBER 11

DELTA (flap deflection anale) versus CHANGE IN PRESSURE COEFFICIENT AT DIFFERENT ANGLES ANGLES OF ATTACK (alpha)

2	***	তিক্ৰ ভ	****	8 3 3 3 2	*******	• • • • • • • • • • • • • • • • • • •	******	***
₹		*		*		*		
* a	lpha	<del>. *</del>	SLOPE	*	INTERCEP1	[ * CC	EFFICIENT	OF
*		*		*		* DE	TERMINATI(	MC
*		*		*		*		
* * *	***	***	<del>(****</del>	***	*****	****	*****	<del>(***</del>
<del>X</del>		*		*		*		
÷	Ø	÷	0.091	*	-0.089	*	0.97	
÷	3	×	0.095	*	-0.115	*	0.84	
÷	6	*	0.098	÷	-0.123	*	0.68	
÷	9	*	0.186	*	-1.060	*	0.91	
÷	_	¥	<del>-</del>	¥		¥		

* :	*****	**.	******	***	******	**	*****	+++
*		×		*		*		*
*	delta	*	SLOPE	*	INTERCEPT	*	COEFFICIENT OF	- *
*		×		*		×	DETERMINATION	*
*		*		*		*		*
* 3	<del>(****</del>	<del>( * ;</del>	*****	***	*****	* * :	******	<del>: * *</del>
*		*		÷		*		*
*	Ø	¥	0.041	*	-0.003	*	1.00	*
*	5	×	-0.060	*	0.180	*	0.92	¥
*	10	*	0.033	*	0.831	*	0.99	*
*	15	*	0.027	*	1.306	*	0.98	*
*		*		*		÷		*
* •	*****	<del>( ) )</del>	******	***	*****	**	******	+ + +

### DELTA P PROJECT SEAP

### RESULTS OF LINEAR CURVE FITTING

FILE NUMBER 77

TAP NUMBER 12

DELTA (flap deflection angle) versus CHANGE IN PRESSURE COEFFICIENT AT DIFFERENT ANGLES ANGLES OF ATTACK (alpha)

* :	****	**:	******	**	******	**	******	**
*		¥		*		÷		*
*	alpha	*	SLOPE	×	INTERCEPT	×	COEFFICIENT OF	÷
÷		¥		*		*	DETERMINATION	*
*		×		¥		*		*
* 3	*****	***	******	**	*****	**	*******	<del>* *</del>
×		×		*		*		*
*	0	*	0.076	×	-0.139	*	0.90	*
*	3	*	0.081	*	-0.193	×	0.76	*
*	6	*	0.087	×	-0.264	×	0.57	*
*	9	×	0.228	*	-1.911	*	0.93	*
×		*		×		¥		*
* 3	*****	<del>( * *</del> *	*****	÷ <del>*</del> ÷	******	**:	*******	**

*	*** ***	÷ <del>*</del> •	*****	**	******	**	*****	***
*		*		*		*		*
×	delta	×	SLOPE	*	INTERCEPT	*	COEFFICIENT O	F *
*		¥		*		*	DETERMINATION	*
*		*		*		*		*
* 3	*****	**	******	***	*****	**	<del>*************</del>	***
*		×		×		×		*
*	0	×	0.030	×	-0.002	*	1.00	*
*	5	*	-0.117	*	0.143	*	0.99	*
*	10	*	0.027	*	0.480	*	1.00	*
*	15	×	0.019	*	1.139	*	0.97	*
÷		*		*		*		*
**	****	+++	******	***	******	***	*******	444

## DELTA P PROJECT SEAP

### RESULTS OF LINEAR CURVE FITTING

FILE NUMBER 78

TAP NUMBER 13

DELTA (flap deflection angle) versus CHANGE IN PRESSURE COEFFICIENT AT DIFFERENT ANGLES ANGLES OF ATTACK (alpha)

÷		×		×		*		*
<del>*</del> a	leha	×	SLOPE	*	INTERCEPT	*	COEFFICIENT OF	. 4
<del>X</del>		*		÷		*	DETERMINATION	*
<del>X</del>		*		×		×		÷
***	****	***	*****	***	<del>(*****</del> ****	<del>2</del> <del>2</del> .	*****	**
*		*		*		×		¥
*	Ø	*	0.036	*	-0.016	*	0.91	¥
*	3	*	0.039	*	-0.035	÷	0.64	*
*	6	÷	0.042	*	-0.059	*	0.41	7
<del>×</del>	9	*	0.120	*	-0.949	*	0.72	*
¥		¥		*		÷		¥

*	*****	* * :	*****	<del>* * * -</del>	******	**	*************	+ +
*		×		*		*		+
÷	delta	*	SLOPE	*	INTERCEPT	÷	COEFFICIENT OF	*
*		×		*		×	DETERMINATION	*
*		×		*		×		÷
+	*****	**	*****	***	******	**	*****	*
*		*		*		×		÷
*	0	¥	0.029	*	-0.002	*	1.00	÷
÷	5	÷	-0.073	*	0.109	×	1.00	*
*	10	*	0.027	×	0.439	*	1.00	*
*	15	÷	0.015	*	0.485	×	0.99	+
+		*		*		*		*
<del>;;</del> ;	*****	+++	*****	***	********	* * :	*****	¥

## APPENDIX D

## THEORETICAL FREQUENCY ANALYSIS DATA

### D.1 LOW DYNAMIC PRESSURE

```
DELTA P FREQUENCY ANALYSIS FC1
******
                         INPUT DATA
                                                      174.0000000
2645.0000000
  Wine Area (DE801)ft+2)
Weight (DE711)1b)
  Wine Span (DE723+ft)
                                                        35.8000000
  MAC (DE733+ft)
                                                        4.9000000
 MRC (DE73](ft)
Airspeed (DE74](ft/s)
Density (DE75](slues/ftf3)
Angle of attack (DE76](rad)
Theta initial (DE77](rad)
Iyyb (DE81](slues-ftf2)
                                                          0.0020500
                                                          0.0000000
                                                          0.0000000
                                                      1346.00000000
  CL1 (DE951)
CD1 (DE961)
                                                          0.3100000
                                                          0.0310000
  CK71 (DE 97 D)
                                                          0.0310000
  CM1 (DE883)
CMT1 (DE893)
                                                          0.0000000
                                                          0.0000000
                                             Dimensional derivatives
  Nondimensional derivatives
                    LONGITUDINAL DEFINATIVES
                        0.0000
                                          20 (1 a)
   CDU (DC 1 1)
                                                              -0.0122
   CRTU (DC23)
CDA (DC33)
                                                              -0.0061
                       -0.0930
                                          NTU (1. ±)
                                                             3.2267
-1.0756
                                          RA GRESTAN
                        0.1300
   CDDE (DC 4 1)
                        0.0600
                                          NDE (ft/s12)
                                         ZU (1-3)
ZH (ft/s†2)
ZHD (ft/s)
   CLU (DE63)
CLA (DE73)
                       0.0000
                                                            -0.1223
-83.0147
                        4.6000
                       1.7000
   CLAD (DESI)
                                                             -0.8214
   CLO (D[9])
CLDE (D[10])
CMU (D[12])
                       3.9000
                                          Z0 (ft/s)
ZDE (ft/sf2)
                                                             -1.8843
-7.7081
                        0.4300
                        0.0000
                                          MÜ (1/463)
                                                              0.0000
   CMTU (DE 131)
                       0.0000
                                          MTU (1/715)
                                                              0.0000
                       -0.8900
                                                              -4.7747
                                          MA (1/st2)
             4 1)
                                                             0.0000
-0.7519
-1.7930
                                          MTH (1/±12)
              :51)
                      0.0000
  CMO + D(171)
                      -5.2000
                                          MAD (1 ±)
                     -12.4000
                                          MQ (1/5)
   CMDE (D:181)
                                          MDE (1 ±12)
                      -1.2800
                                                             -6.8669
```

# DELTA P FREQUENCY ANALYSIS FC1

### TRANSFER FUNCTION POLYNOMIAL COEFFICIENTS

THE COEFFICIENTS OF THE LONGITUDINAL CHARACTERISTIC EQUATION ARE:
A= 91.72136 B= 316.08207 C= 580.02367
D= 14.18981 E= 18.78257

THE COEFFICIENTS OF THE NUMERATOR U(\$) ARE: 0.00000 AU= -98.65111 BU= -363.02499 CU= 17443.94743 BU= 17156.83612

THE COEFFICIENTS OF THE NUMERHTOR ALPHA(\$) ARE:
0.00000 AA= -7.70812 BA= -625.09400
-11.22826 DA= -27.01314

THE COEFFICIENTS OF THE NUMERATOR THETA(S) ARE:
0.00000 0.00000 A74 -624.04734
-544.79548 CT= -13.11681

STANDARD FORMAT FOR LONGITUDINAL TRANSFER FUNCTIONS

### U(\$)/DELTA-E(\$) COEFFICIENTS ARE:

CA=

KUDE 913.44451
TU1 1.03184
TU2 0.06748
TU3 -0.08258
OMN SP 2.50357
ZT SP 0.68689
OMN P 0.18075
ZT P 0.01869

### ALPHA(S)/DELTA-E(S) COEFFICIENTS ARE:

KALPHADE -1.43820
TRLPHA1 0.01233
CMN ALFHA 0.20790
ZT ALFHA 0.04193
OMN SP 2.50357
ZT SP 0.68689
OMN P 0.18075
ZT P 0.01869

### THETA(S)/DELTA-E(S) COEFFICIENTS ARE:

KTHETADE -0.69835 TTHETA1 40.35522 TTHETA2 1.17893 OMN SP 2.50357 ZT SP 0.68689 OMN P 0.18075 ZT P 0.01869

OF POOR OF PAGE 18

### D.1.1 WITH PRESSURE SENSOR (PRESSURE COMMAND)

```
DELTA P FREQUENCY ANALYSIS FOI
     HO'S' COEFFICIENTS
     1.000E 01 5.000E 01
DO:S: COEFFICIENTS
       1.000E 00 1.500E 01 7.000E 01
     N1:3: COEFFICIENTS
     6.240E 02 5.448E 02 1.310E 01
D1 5 COEFFICIENTS
                     3.161E 02 5.800E 02 1.420E 01 1.880E 01
       9.170E 01
     H2:S: COEFFICIENTS
       1.000E 00
     D2(S) COEFFICIENTS
       1.000E 00
    NC 0 INC 1 IDC 2 I=
    6.249E 03 3.665E 04 2.737E 04 6.550E 02 NEO INC 1 INC 2 I=
       6.240E 03 | 3.665E 04 | 2.737E 04 | 6.550E 02
                                                               Feel 1.00% 000 -5.000
                  Peol Imaginary
-0.025 0.000
  POOT NO. 3
                                             POOT NO. 2
  FOOT NO. 1 -0.848
                               0.000
        0.000
    DE 0 DE 1 DE 2 1+1 HE 0 JHE 1 JHE 2 1#
       9.170E 01 | 1.692E 03 | 1.174E 04 | 3.084E 04 | 4.093E 04 | 1.174E -
                    Peo 1
                                                                  F401
                                                                          1,1821,29
                             Ind #indrs
                                                               -7.500
                                                                          -0.1 1
0.111
  POOT NO. 6 -7.500 -3.708
FOOT NO. 4 -1.720 -1.819
FOOT NO. 2 -1.720 1.819
  POOT NO. €
                                              POOT NO. 5
POOT NO. 3
POOT NO. 1
                                                              -0.003
                                                               -0.003
K.≢
        0.200
     DE 0 3DE 1 3DE 2 3+KHE 0 3NE 1 3NE 2 3=
       9.170E 01 | 1.692E 03 | 1.174E 04 | 3.209E 04 | 4.816E 04 | 6.750E 00
       1.447E 03
                                                                  Real
                                                                           Ind sindre
                    Real
                             Imaginary
                                                               -7.495
-0.066
                                               ROOT NO. 5
ROOT NO. 3
  2001 HO. 6
                  -7.435
                             -3.553
                                                                           3.553
                                                                           -0.170
                             -2.043
2.043
  ROOT NO. 4 -1.663
ROOT NO. 2 -1.663
                 -1.663
                                               ROOT NO. 1
                                                               -0.056
                                                                            0.170
        0.500
     DE 0 3DE 1 3DE 2 3+KHE 0 3HE 1 3HE 2 3=
       9,170E 01 | 1,692E 03 | 1,174E 04 | 3,396E 04 | 5,916E 04 | 1,496E 04
       1.644E 03
                                                                  F & 1 1
                                                                           Lasinari
                    Real
  Red1
F00T NO. 6 -7.497
F00T NO. 4 -1.588
F00T NO. 2 -1.589
                             Ina#inary
                                               ROOT HO. 5
ROOT HO. 3
ROOT HO. 1
                                                               -7.497
                             -3.314
-2.374
                                                                           3. 114
                                                               -0.113
                                                                           -0.116
                                                                           0.115
                               2.374
        0.800
     DEO DE 1 DE 21+1 NEO DE 1 DE 21=
       9.170E 01 1.692E 03 1.174E 04 3.580E 04 7 015E 04 1.117E 04
       1.840E 03
                                                                         3 = 1 + 1 + 1 + 2 +
                     Reol
                             Ind #inar.
                                                             POOT NO. 5
  F007 H0. 6
F007 H0. 4
F007 H0. 2
                 -7.512
-1.520
-1.520
                             -3.068
-2.692
2.692
                                                                             . .....)
                                                                           .....
                                               8001 NO. 1
```

```
1.000
     DE 0 3DE 1 3DE 2 3+6 NE 0 3NE 1 3NE 2 3+
       3.170E 01 | 1.692E 03 | 1.174E 04 | 3.708E 04 | 7.749E 04 | 1.965E 04
       1.971E 03
                             Indainer/
                                                               5401
51.475
                                                                           1 3 4 3 3 6
                             -2.902
2.902
                                              FOOT NO. 5
FOOT NO. 3
FOOT NO. 1
  POOT NO. 6
                  -7.528
-7.528
                                                                          -1. 1.4
-0.000
  FOOT NO. 4
FOOT NO. 2
                                                               ----
                  -1,476
                               2.834
                                                               -4. 4-
                                                                           1. (2.13)
        2.000
    DE 0 1DE 1 1DE 2 1+KHE 0 1HE 1 1HE 2 1=
       9.170E 01
2.625E 03
                    1.692E 03 1.174E 04 4.732E 04 1.141E 05 5.602E 04
                  Red1
-1.253
-7.671
-1.253
                             Imaginary
-3.784
-2.031
                                                                          2.014
0.000
                                                                 Peol
                                              POOT HO. 5
POOT HO. 3
POOT HO. 1
                                                               -7.671
  P001 no. 6
  POOT NO. 4
POOT NO. 2
                                                               -0.052
-0.54
k=
        3.000
     DE O JDE 1 JDE 2 J+KHE O JNE 1 JNE 2 J=
                    1.692E 03 1.174E 04 .CU6E 04 1.508E 05 8.339E 04
       9.170E 8"
       3.281E 03
                                                                 Real
                     Real
                              Imaginary
                                                                           Ind windre
  ROOT NO. 6
ROOT NO. 4
ROOT NO. 2
                  -1.021
                              -4.491
                                               ROOT NO. 5
                                                               -7.865
                                                                            0.902
                              -0.902
                                               ROOT NO. 3
                                                                           -0.000
                                                               -0.043
                  -7.265
                                                                            0.000
                                               ROOT NO. 1
                                                               -0.632
                 -1.021
                               4.491
K=
        4.000
     DEO JDE 1 JDE 2 J+KNE O JHE 1 JHE 2 J=
       9.170E 01 1.692E 03 1.174E 04 5.580E 04 1.874E 05 1.108E 05
       3.936E 03
                                                                 Peal
                     Real
                             Imaginary
                                                                           Ima@inar-
  ROOT NO. 6
                             -5.067
                  -0.797
                                               ROOT NO. 5
                                                               -9.423
                                                                            0.000
                 -6.712
-0.797
                                               ROOT NO. 3
ROOT NO. 1
                                                               -0.038
  ROOT NO. 4
                              0.000
                                                                           -0.000
  ROOT NO. 2
                               5.067
                                                               -0.630
                                                                            0.000
        5.000
Ke
    DEG JDE 1 JDE 2 J+KHE G JHC 1 JHC 2 J=
       9.170E 01 | 1.692E 03 | 1.174E 04 | 6.204E 04 | 2.241E 05 | 1.381E 05 | 4.591E 03
                                                                 Real
                                                                          Imaginer:
                     Real
                             Inaginary
  ROOT HO. 6
                  -0.589
-6.244
                             -5.551
                                               POOT NO. 5
                                                              -10.280
                                                                            0.000
  ROOT NO. 4
                             -0.000
                                                              -0.035
                                                                           -0.000
                                                                            0.000
  ROOT NO. 2
                                               ROOT NO. 1
                  -0.589
                               5.551
                                                               -0.710
        6.000
    DE0 3DE1 3DE2 3+KNF 0 3HE 1 3NE 2 3=
       9.170E 01 1.692E 03 1.174E 04 6.829E 04
                                                              2.607E 05 1.655E 05
       5.246E 03
                    Real
                                                                 Reol
                                                                           Imoginar.
                             Imaginary
  POOT NO. 6
                             -5.971
                                               FOOT NO. 5
FOOT NO. 3
FOOT NO. 1
                                                              -10.901
                                                                            0.000
                  -0.396
  F00T NO. 4
F00T NO. 2
                              0.000
                                                              -0.033
-0.732
                  -5.989
                                                                           0.000
                  -0.396
                              5.971
                                                                          -0.000
       7.000
    DCODDC1DDC2D+KHCODHC1DHC2D=
       9.170E 01
5.901E 03
                    1.692E 03 1.174E 04 7.452E 04 2.974E 05 1.929E 05
                    Real
                                                                 Peol
                             Imaginer:
                                                                          Ind #indr .
                                               POOT NO. 5
                                                              -11.409
-0.032
-0.747
  ROOT NO. 6
                                                                          -0.000
                  -0.213
                             -6,504
  ROOT NO. 4
ROOT NO. 2
                                                                            0.000
                  ~5.323
                             ~9.000
                                               POOT NO. 1
                                                                            0.000
                  -0.218
                              6.344
        3.000
    DE 0 1DE 1 1DE 2 1-41/2 0 1HE 1 1HE 2 1=
                    1.692E 03 1.174F 04 3.076E 04 1.340E 05 3.101E 05
       9.170E 61
       6.556E 03
                    Peal
                                                                 F-01
                                                                          Ind #160 f
                             Ind #indra
                 -0.050
-0.050
                                              FOOT NO. 5
FOOT NO. 1
                                                                          \phi_{+}(\phi_{0})
  ROOT NO. 6
                             -6.679
                                                              -11.345
                              0.000
                                                             -0.001
-0.759
  F00T H0. 4
                                                                          -0.000
                                                                          -0.000
                  -0.950
                              6.679
```

```
7.000
K#
     D( 0 3D( 1 3D( 2 3+KHC 0 3HC 1 3HC 2 3=
        9.170E 01 | 1.692E 03 | 1.174E 04 | 7.452E 04 | 1.374E 05 | 1.413E 05
        5.901E 03
                                                                      Pegl
                      Real
                               Inatinary
                                                                                Laternary
                                                  ROOT HO. 5
ROOT HO. 3
ROOT HO. 1
  ROOT NO. 6
                                                                -11.403
-0.032
-0.747
                   -0.218
                               -6.344
                                                                                -0.000
  ROOT NO. 4
ROOT NO. 2
                               -0.000
                                                                                3.000
                   -5.823
                                 6.344
                                                                                 0.000
                    -0.213
        8.000
     DC 0 3DC 1 3DC 2 3+KHC 0 3HC 1 3HC 2 3=
                    1.692E 03 1.174E 04 8.076E 04 3.040E 05 2.100E 05
       9.170E 01
6.556E 03
                                                 ROOT NO. 5 -11.845
ROOT NO. 3 -0.031
ROOT NO. 1 -0.759
                                                                                Las siner .
                      Real
                               Imaginary
  ROOT NO. 6
ROOT NO. 4
ROOT NO. 2
                   -0.053
-5.706
                               -6.679
0. 30
                                                                                0.000
                                                                                -0.000
                                 6.679
                                                                                -0.000
                   -0.053
       9.000
     DE 0 1DE 1 1DE 2 1+KHE 0 1HE 1 1HE 2 1=
                    1.692E 03 1.174E 04 8.700E 04 3.707E 05 2.476E 05
       9.170E 01
7.211E 03
                      Real
                                                                      Reol
                                                                               Ind windr.
                               Imaginary
                                                  ROOT NO. 5
ROOT NO. 3
ROOT NO. 1
                               -6.986
0.000
                                                                 -12.233
0.102
  ROOT NO. 6
                                                                               -0.000
                    0.102
                                                                               6. 3. 6
  ROOT NO. 4
ROOT NO. 2
                   -0.031
                   -5.618
                                0.000
                                                                   -0.768
                                                                               -0.000
       10.000
     DE 0 1DE 1 3DE 2 3+KHE 0 3HE 1 3HE 2 3#
       9.170E 01 | 1.692E 03 | 1.174E 04 | 9.324E 04 | 4.073E 05 | 2.750E 05 | 7.866E 03
                               Imaginary
-7.268
                      Real
                                                                      Regl
                                                                               Indament.
                                                                 -12.594
0.247
-0.776
                                                 FOOT NO. 5
                                                                               -0.000
7.263
                   0.247
-0.030
  ROOT NO. 6
  ROOT NO. 4
                               6.000
  ROOT NO. 2
                   -5.550
                               -0.000
                                                  ROOT NO. 1
                                                                               -0.000
```

## D.1.2 WITHOUT PRESSURE SENSOR (POSITION COMMAND)

DELTA P THEORETICAL ANALYSIS

NO(S) COEFFICIENTS
1.000E 01
DO(S) COEFFICIENTS
1.000E 00 1.000E 01
N1(S) COEFFICIENTS
6.240E 02 5.448E 02 1.310E 01
D1(S) COEFFICIENTS
9.170E 01 3.161E 02 5.800E 02 1.420E 01 1.880E 01
N2(S) COEFFICIENTS
1.000E 00
D2(S) COEFFICIENTS
1.000E 00

### NC 0 JNC 1 JDC 2 J=

美

6.240E 03 5.448E 03 1.310E 02 NC0 JNC1 JNC2 J=

6.240E 03 5.448E 03 1.310E 02
Real Imaginary Real Imaginary
ROOT NO. 2 -0.025 0.000 ROOT NO. 1 -0.848 0.000

### K= 0.000 DE 0 DDC 1 DDC 2 D+KNC 0 DNC 1 DNC 2 D=

9.170E 01 1.233E 03 3.741E 03 5.814E 03 1.608E 02 1.880E 02 Real -1.720 Real Imaginary Imaginary ROOT HO. 4 ROOT NO. 2 -10.000 -0.000 **ROOT NO. 5** -1.819 ROOT NO. 3 -0.003 -0.181 -1.7201.819 ROOT NO. 1 -0.003 0.181

### K= 0.200 DC 0 JDC 1 JDC 2 J+KNC 0 JNC 1 JNC 2 J=

9.170E 01 1.233E 03 3.741E 03 7.062E 03 1.250E 03 2.142E 02 Real -10.167 Inaginary Real Imaginary **ROOT NO. 5** ROOT NO. 4 ROOT NO. 2 -1.552 -2.111 0.000 ROOT NO. 3 ROOT NO. 1 -0.089 -0.160 -1.5522.111 -0.089 0.160

### K= 0.500 DE 0 JDE 1 JDE 2 1+KNE 0 JNE 1 JNE 2.3=

9.170E 01 1.233E 03 3.741E 03 8.934E 03 2.885E 03 2.535E 02 Real Imaginary -10.397 0.000 Real Imaginary ROOT NO. 5 ROOT NO. 3 ROOT NO. 4 ROOT NO. 2 -1.345 -2.504 0.000-0.130 -0.021 -1.345 2.504 ROOT NO. 1 -0.130 0.021

### K= 0.800 DE0 JDE1 JDE2 J+KHE0 JHE1 JHE2 J=

9.170E 01 1.233E 03 3.741E 03 1.081E 04 4.519E 03 2.928E 02 Real Imaginary Real Imaginary ROOT NO. 4 ROOT NO. 2 **ROOT NO. 5** -1.181 -2.349 -10.607 0.000 -0.079 ROOT NO. 3 9.000 2.849 -1.131 ROOT NO. 1 -0.393 0.000

```
1.000
K=
    D[ 0 ]D[ 1 ]D[ 2 ]+KN[ 0 ]N[ 1 ]N[ 2 ]=
       9.170E 01 1.233E 03 3.741E 03 1.205E 04 5.609E 03 3.190E 02
                                                         Real Imaginary
                   Real
                          lmaginary
                                         ROOT NO. 4 -10.739
ROOT NO. 2 -1.088
                                                                  -0.000
                          -3.056
  ROOT NO. 5
                -1.088
                                                                   3.056
  ROOT NO. 3
                           0.000
                -0.066
                -0.466
                           0.000
   ROOT NO. 1
        2.000
    DC 0 1DC 1 3DC 2 3+KNC 0 3NC 1 3NC 2 3=
       9.170E 01 1.233E 03 3.741E 03 1.829E 04 1.106E 04 4.500E 02
                                                                  Imaginary
                   Real
                          Inasinary
                                                          Real
                                        ROOT NO. 4
                          ~3.892
                -0.728
   ROOT NO. 5
                                                       -11.317
                                                                   0.000
                                                        -0.728
                                                                   3.892
                          0.000
  ROOT NO. 3
                -0.044
  ROOT NO. 1
                 -0.631
                          -0.000
K=
        3.000
    DC 0 JDC 1 JDC 2 ]+KNC 0 JNC 1 JNC 2 ]=
       9.170E 01 1.233E 03 3.741E 03 2.453E 04 1.650E 04 5.810E 02
                         Inaginary
                                                         Real Imaginary
                  Real
  ROOT NO. 5
                -0.456
                                         ROOT NO. 4 -11.802
ROOT NO. 2 -0.456
                          -4.525
                                                                  -0.000
  ROOT NO. 3
                -0.037
                          -0.000
                                                                   4.525
  ROOT NO. 1
                -0.697
                          -0.000
        4.000
K=
    DC 0 3DC 1 3DC 2 3+KNC 0 3NC 1 3NC 2 3=
      9.170E 01 1.233E 03 3.741E 03 3.077E 04
                                                      2.195E 04 7.120E 02
                  Real
                          Indginary
                                                          Real Imaginary
  ROOT NO. 5
                -0.228
                          -5.043
                                         ROOT NO. 4
ROOT NO. 2
                                                      -12.225
                                                                  -0.000
  ROOT NO. 3
               -0.034
                          -0.000
                                                       -0.223
                                                                   5.043
  ROOT NO. 1
                -0.732
                          -0.000
K=
       5.000
    D[ 0 ]D[ 1 ]D[ 2 ]+KN[ 0 ]N[ 1 ]N[ 2 ]=
      9.170E 01 1.233E 03 3.741E 03 3.701E 04 2.740E 04 8.430E 02
                  Real
                        Imaginary
                                                                Inaginary
                                                         Real
  ROOT NO. 5
ROOT NO. 3
                                         RQOT NO. 4
ROOT NO. 2
                                                      -12.603
                -0.029
                          -5.485
                                                                  0.000
                           0.000
                -0.032
                                                       -0.029
                                                                  5.485
  ROOT NO. 1
                -0.754
                           0.000
       6.000
    DE 0 3DC 1 3DC 2 3+KNC 0 3NC 1 3NC 2 3=
      9.170E 01 1.233E 03 3.741E 03 4.325E 04
                                                      3.285E 04 9.740E 02
                  Real
                          Imaginary
                                                         Real
                                                                 Imaginary
  ROOT NO. 5
                                         ROOT NO. 4
ROOT NO. 2
                 0.149
                          -5.873
                                                      -12.946
                                                                  0.000
  ROOT NO. 3
                -0.031
                           0.000
                                                        0.149
                                                                  5.873
  ROOT NO. 1
                -0.769
                          -0.000
       7.000
    DE 0 JDE 1 JDE 2 J+KNE 0 JNE 1 JNE 2 J=
      9.170E 01 1.233E 03 3.741E 03 4.949E 04
                                                      3.830E 04 1.105E 03
                         Imaginary
                  Real
                                                                 Inaginary
                                                         Real
 ROOT NO. 5
                                         ROOT NO. 4
                                                      -13.261
                 0.312
                          -6.222
                                                                  0.000
 ROOT NO. 3
                                         ROOT NO. 2
                                                        0.312
               -0.030
                          0.000
                                                                  6.222
  ROOT NO. 1
                -0.780
                         -0.000
       8.000
    DC 0 JDC 1 JDC 2 3+KNC 0 JHC 1 JNC 2 ]=
      9.170E 01 1.233E 03 3.741E 03 5.573E 04 4.374E 04 1.236E 03
                  Real
                         Imaginary
                                                         Real Imaginary
 ROOT NO. 5
                                         ROOT NO. 4
                0.462
                          -6.540
                                                     -13.554
                                                                  0.000
 ROOT NO. 3
ROOT NO. 1
                                         ROOT NO. 2
               -0.029
                          0.000
                                                        0.462
                                                                  6.540
               -0.738
```

0.000

**)**;

***

### K= 9.000 DE0 JDE 1 JDE 2 J+KNE 0 JNE 1 JNE 2 J=

9.170E 01 1.233E 03 3.741E 03 6.197E 04 4.919E 04 1.367E 03 Real Imaginary Real Imaginary Real Imaginary Root No. 5 0.603 -6.832 ROOT NO. 4 -13.829 -0.000 ROOT NO. 3 -0.029 0.000 ROOT NO. 2 0.603 6.832 ROOT NO. 1 -0.795 -0.000

K= 10.000 "[0]D[1]D[2]+KN[0]N[1]N[2]=

ŧ.

9.170E 01 1.233E 03 3.741E 03 6.821E 04 5.464E 04 1.498E 03 Real Imaginary Real Imaginary Real Imaginary Root No. 5 0.734 -7.104 ROOT NO. 4 -14.087 -0.000 ROOT NO. 3 -0.028 -0.000 ROOT NO. 2 0.734 7.104 ROOT NO. 1 -0.800 0.000

### D.2 HIGH DYNAMIC PRESSURE

CMDE + DC 181+

-1.2800

#### DELTA P FREQUENCY ANALYSIS FOI INPUT DATA Wins Area (DES01)ftt2) 174,000000000 2645.00000000 Weight (DE711-1b) Hins Span (BE721) (t) MAC (BE731) (t) 05.00000000 4.9000000MHC (DETS) PTT) Hirspeed (DET4 lettes) Density (DET5 les lusse et t3) Angle of attack (DET5 lenade Theta initial (DET7 lenade) 272.0000000 0.0020500 0.00000000 0.0000000 1346.00000000 Iv.b (DISI halusa-+**12) CL1 DE951) 0.3100000 CD1 (DC961) 0.0310000 0.0310000 COT1 ( DE 97 1) CM1 · DC88 I) ត្ត, តូតូតូតូតូតូត 0.00000000 CMT1 + D(891) Bimensional deriverives Mondimensional derivatives LONGITUDINAL DEPIVATIVES -0.0367 0.0000 13U × 1 (± ) CDU + DE 1 15 -0.0183 NTU +1 ±+ CHITO + DC 2 DE -0.0930MA KEN ETZ) 29.0612 CDA - DEGIA 0.1300NDE (++ st2) -9.6871 -0.3669 CDDE (D[41) 0.0600 ZDE (ff at2) ZA (ff at2) ZAD (ff at ZO (ff at ZDE (ff (at2) CLU - D[6]) CLA - D[7]) 0.00004.6000 1.7000 3.9000 -747.6804 -2.4650 -5.6549 CLAD (DESI) CLDE (D[9]) -69.4240 0.4300 0.0000 0.0000 CMU (DC121) MU (1) ftax 0.0000 CMTU (DC 131) MTU (1 fts) 0.0000 0.0000 CMA (DC141) MA (1 at2) -43.0034 -0.8900 CMTA (DC 151) 0.0000 MTA +1/2/2/ 0.0000 MAD (1 g) -2.2565 -5.3809 CMAD (DE 161) -5.2000 MDE +1 =12) CM0 (DE171) -12.4000

-61.8476

```
DELTA P FREQUENCY ANALYSIS FC1
```

### TRANSFER FUNCTION POLYNOMIAL COEFFICIENTS

```
THE COEFFICIENTS OF THE LONGITUDINAL CHARACTERISTIC EQUATION ARE:
-- A= 275.26497 B= 2846.82537 C= 15677.87370
D= 937.76723 E= 507.68751
```

THE COEFFICIENTS OF THE NUMERATOR UPSA APE:

0.00000 AU= +2666.51129 BU= -29448.17973

CU= -98568.06981 DU= 1391743.28349

THE COEFFICIENTS OF THE NUMERATOR ALPHA(S) ARE:
0.00000 AA= -69.42401 BA= -16896.11196
CA= -910.82371 DA= -730.15732

THE COEFFICIENTS OF THE NUMERATOR THETA(S) ARE: 0.00000 0.00000 AT= -16867.82100 BT= -44193.19758 CT= -3193.23231

STANDARD FORMAT FOR LONGITUDINAL TRANSFER FUNCTIONS

### U(S)/DELTA-E(S) COEFFICIENTS ARE:

KUDE	2741.33843
TU1	-0.21267
OMN U	10.53575
ZT U	0.74725
OMH SP	7.50749
ZT SP	0.68516
OMN P	0.18090
IT P	0.15056

### ALFHA(S)//DELTA-E(S) COEFFICIENTS ARE:

MALPHADE	-1.43820
TALPHAI	0.00411
OMN ALPHA	0.20790
IT ALPHA	0.12923
OMN SP	7.50749
ZT SP	0.68516
OMN P	0.18090
ST P	0.15056

### THETA(S)/DELTA-E(S) COEFFICIENTS ARE:

) THETADE	-6.28976
TTHETA1	13.44681
TTHETAS	0.39283
OMN SP	7.50749
27 SP	0.68516
OMN F	0.18090
ZT P	0.15056

## D.2.1 WITH PRESSURE SENSOR (PRESSURE COMMAND)

```
DELTA P FREQUENCY ANALYSIS FC1
    NO(S) COEFFICIENTS
      1.000E 01 5.000E 01
    DO(S) COEFFICIENTS
    1.000E 00 1.500E 01 2.295E 02
N1(S) COEFFICIENTS
       1.687E 04 4.419E 04 3.193E 03
    D1(S) COEFFICIENTS
       2.753E 02 2.847E 03 1.568E 04 9.378E 02 5.077E 02
    N2(S) COEFFICIENTS
       1.000E 00
    D2(S) COEFFICIENTS
      1.000E 00
    NC 0 JNC 1 JDC 2 J=
    1.687E 05 1.285E 06 2.343E 06 1.597E 05 NEO JNC1 JNC2 J=
       1.687E 05 1.285E 06 2.242E 06 1.597E 05
                   Real
                           Imaginary
                                                            Real
                                                                     Imaginary
  ROOT NO. 3
ROOT NO. 1
                 -0.074
                            0.000
                                           ROOT NO. 2
                                                          -5.000
                                                                      0.000
                            0.000
                -2.546
K=
       0.000
    DE 0 3DE 1 3DE 2 3+KNE 0 3NE 1 3NE 2 3=
      2.753E 02
1.165E 05
                   6.976E 03 1.216E 05 8.894E 05 3.613E 06 2.228E 05
                   Real
                           Imaginary
                                                             Real
                                                                     Imaginary
                -7.500
-7.500
                                                          -5.143
  ROOT NO. 6
                        -13.152
                                           ROOT NO. 5
                                                                     -5.468
                                           ROOT NO. 3
ROOT NO. 1
  ROOT NO. 4
ROOT NO. 2
                         13.162
                                                          -5.143
                                                                      5.463
                -0.027
                           -0.179
                                                          -0.027
                                                                      0.179
       0.200
    D[ 0 ]D[ 1 ]D[ 2 ]+KN[ 0 ]N[ 1 ]N[ 2 ]=
       2.753E 02 6.976E 03 1.216E 05 9.232E 05
                                                         3.870E 06 6.712E 05
      1.484E 05
                                                             Real
                                                                     Inaginary
                           Imaginary
                   Real
                                            ROOT NO. 5
ROOT NO. 3
                 -7.129 -13.026
                                                           -7.129
                                                                      13.026
  ROOT NO. 6
                                                           -5.455
                                                                       5.600
  ROOT NO. 4
ROOT NO. 2
                 -5.455
                           -5.600
                                                           -0.086
                 -0.086
                            -0.181
                                            ROOT NO. 1
                                                                       0.181
    D[ 0 3D[ 1 3D[ 2 3+KH[ 0 3H[ 1 3H[ 2 3=
                  6.976E 03 1.216E 05 9.738E 05 4.255E 06 1.344E 06
       2.753E 02
1.963E 05
                                                             Real
                                                                      Imaginary
                   Real
                           Imaginary
                                                           -5.993
-5.993
                                                                      -5.725
5.725
  ROOT NO. 6
ROOT NO. 4
                                            ROOT NO. 5
                 -6.513
                          -12.386
                 -6.513
                                            ROOT NO. 3
                           12.886
                           -0.151
                                            ROOT NO. 1
                                                           -0.165
                                                                       0.151
  ROOT NO. 2
                 -0.165
        0.800
    DE O IDE 1 IDE 2 I+KNE O INE 1 INE 2 I=
                   6.976E 03 1.216E 05 1.024E 06 4.641E 06 2.016E 06
       2.753E 02
       2.442E 05
                                                           Real
-6.579
                                                                     Imaginary
                   Real
                           Imaginary
                                                                     -5.723
-0.059
                 -5.857
-5.857
                         -12.859
                                            ROOT NO. 5
  ROOT NO. 6
                                            POOT NO. 3
ROOT NO. 1
                                                           -0.234
                           12.859
  ROOT NO. 4
                                                           -0.234
                                                                       0.059
  ROOT NO. 2
                 -6.579
```

```
1.000
K=
  . DE 0 3DE 1 3DE 2 3+KNE 0 3NE 1 3NE 2 3=
       2.753E 02 6.976E 03 1.216E 05 1.058E 06 4.898E 06 2.464E 06
       2.762E 05
                    Real
                            Imaginary
                                                              Real
                                                                       Imaginary
                                            ROOT NO. 5
ROOT NO. 3
ROOT NO. 1
  ROOT NO. 6
                 -5.428
-5.428
                           -12.910
12.910
                                                            -6.966
                                                                       -5.646
  ROOT NO. 4
                                                            -0.163
                                                                       -0.000
  ROOT NO. 2
                             5.646
                 -6.966
                                                            -0.390
                                                                        0.000
       2.000
    DE 0 JDE 1 JDE 2 J+KNE 0 JNE 1 JNE 2 J= .
      2.753E 02 6.976E 03 1.216E 05 1.227E 06 6.183E 06 4.706E 06 4.358E 05
                                                            Real
-3.720
                    Real
                           Imaginary
                                                                       Inaginary
                                            ROOT NO. 5
ROOT NO. 3
  ROOT NO. 6
                 -3.720
                           -13.588
                                                                       13.588
  ROOT NO. 4
ROOT NO. 2
                 -8.505
                           -4.726
                                                            -0.107
                                                                        0.000
                                            ROOT NO. 1
                 -8.505
                             4.726
                                                            -0.784
                                                                        0.000
         3.000
 K=
     D[ 0 ]D[ 1 ]D[ 2 ]+KN[ 0 ]N[ 1 ]N[ 2 ]=
        2.753E 02 6.976E 03 1.216E 05 1.395E 06 7.469E 06 6.948E 06
        5.955E 05
                                                               Real
                                                                        Imaginary
                    Real
                             Imaginary
                                             ROOT NO. 5
ROOT NO. 3
ROOT NO. 1
   ROOT NO. 6
                -2.572
-2.572
                                                             -9.533
                          -14.384
                                                                        -3.408
                           14.384
                                                            -0.095
                                                                        -0.000
   ROOT NO. 4
   ROOT NO. 2
                  -9.533
                              3.408
                                                             -1.037
                                                                        -0.000
        4.000
 K=
     DE 0 JDE 1 JDE 2 J+KNE 0 JNE 1 JNE 2 J=
        2.753E 02 6.976E 03 1.216E 05 1.564E 06 8.754E 06 9.189E 06
        7.552E 05
                    Real
                             Imaginary
                                                               Real
                                                                        Imaginary
                                             ROOT NO. 5
ROOT NO. 3
   ROOT NO. 6 -1.707
ROOT NO. 4 -10.307
ROOT NO. 2 -10.307
                           -15.119
                                                             -1.707
                                                                        15.119
                                                            -0.090
                            -1.336
                                                                        -0.000
                                             ROOT NO. 1
                              1.336
                                                             -1.223
                                                                        -0.000
        5.000
     D[ 0 ]D[ 1 ]D[ 2 ]+KN[ 0 ]N[ 1 ]N[ 2 ]=
        2.753E 02 6.976E 03 1.216E 05 1.733E 06 1.004E 07 1.143E 07
      9.148E 05
                    Real
                             Imaginary
                                                               Real
                                                                        Imaginary
   ROOT NO. 6
ROOT NO. 4
                                             ROOT NO. 5
                                                           -13.618
                                                                        -0.000
                          -15.788
                  -1.007
                                             ROOT NO. 3
                  -0.087
                            0.000
                                                            -1.007
                                                                        15.788
   ROOT NO. 2
                  -8.258
                             -0.000
                                             ROOT NO. 1
                                                             -1.365
                                                                         0.000
         6.000
     DC 0 JDC 1 JDC 2 J+KNC 0 JNC 1 JNC 2 J=
        2.753E 02 6.976E 03 1.216E 05 1.902E 06 1.132E 07 1.367E 07 1.074E 06
                           Imaginary
                    Real
                                                               Real.
                                                                        Imaginary
                  -0.412 -16.399
-0.084 -0.000
                                             ROOT NO. 5
ROOT NO. 3
   ROOT NO. 6
                                                           -15.408
                                                                        0.000
   ROOT NO. 4
                                                                       16.399
                                                            -0.412
   ROOT NO. 2
                                                                       -0.000
                  -7.546
                              0.000
                                             ROOT NO. 1
                                                            -1.478
         7,000
     DC 0 JDC 1 JDC 2 J+KNC 0 JNC 1 JNC 2 J=
        2.753E 02
1.234E 06
                    6.976E 03 1.216E 05 2.070E 06 1.261E 07 1.591E 07
                    Real
                                                               Real
                            Inaginary
                                                                       Imaginary
   ROOT NO. 6
                                             ROOT HO. 5
ROOT HO. 3
ROOT HO. 1
                                                           -16.765
0.107
                   0.107
                          -16.962
                                                                       -0.000
   POOT NO. 4
                                                                       16,962
                  -0.083
                            -0.000
   ROOT NO. 2
                                                                       -0.000
                  -7.136
                              0.000
                                                            -1.570
```

```
K=
       8.000
     DE 0 JDE 1 JDE 2 J+KHE 0 JHE 1 JHE 2 J=
        2.753E 02 6.976E 03 1.216E 05 2.239E 06 1.390E 07 1.816E 07
        1.394E 06
                     Real
                             Imaginary
                                                                           Imaginary
                                               ROOT NO. 5
ROOT NO. 3
ROOT NO. 1
                    0.570
                                                              -17.894
0.570
   ROOT HO. 6
ROOT HO. 4
ROOT HO. 2
                           -17.487
-0.000
                                                                            0.000
                                                                           17.487
                   -0.082
                  -6.857
                                                               -1.647
                               0.000
        9.000
 K=
     DC 0 3DC 1 3DC 2 3+KHC 0 3NC 1 3NC 2 3=
        2.753E 02 6.976E 03 1.216E 05 2.408E 06 1.518E 07 2.040E 07
        1.553E 06
                                                                  Real
                     Real
                              Imaginary
                                                                           Imaginary
                            -17.977
-- ROOT NO. 6
                    0.989
                                                ROOT NO. 5
                                                             -18.875
                                                                            0.000
   ROOT NO. 4
POOT NO. 2
                                                ROOT NO. 3
                   -0.081
                            -0.000
                                                                0.989
                                                                           17.977
                   -6.651
                                                ROOT NO. 1
                               0.000
                                                                -1.712
                                                                           -0.000
     10.000
     DC 0 1DC 1 3DC 2 1+KHC 0 1NC 1 1NC 2 ]=
        2.753E 02 6.976E 03 1.216E 05 2.576E 06 1.647E 07 2.264E 07 1.713E 06
                      Real
                              Imaginary
                                                                   Real
                                                                            Imaginary
   ROOT NO. 6 1.373
ROOT NO. 4 -0.080
ROOT NO. 2 -6.490
                                                ROOT NO. 5
ROOT NO. 3
                    1.373 -18.439
-0.080 0.000
                                                               -19.749
1.373
-1.768
                                                                           0.000
18.439
0.000
                            -0.000
                                                ROOT HO. 1
```

### D.2.2 WITHOUT PRESSURE SENSOR (POSITION COMMAND)

```
TELTA A FEETLENCY ANALYSIS
     HO(S) COEFFICIENTS
       1.000E 01
     DO(S) COEFFICIENTS
     1.000E 00 1.000E 01

MICS/ COEFFICIENTS

1.687E 04 4.419E 04 0.197E 03

DICS/ COEFFICIENTS

2.757E 02 3.847E 03 1.568E 04 3.378E 02 7.077E 02
     N2(S) COEFFICIENTS
       1.000E 00
     D2(S) COEFFICIENTS
       1.000E 00
    HE O THE 1 100 2 1=
       1.687E 05 4.419E 05 3.193E 04
    NCO INC 1 INC 2 Ja
       1.687E 05 4.419E 05 3.193E 04
                    Feal Imaginary
                                                             Peol
                                                                    1.00 310 37
                                            ROOT NO. 1
  ROOT HO. 2
                 -0.074
                             0.000
                                                           -1.546
                                                                       0.000
       0.000
    DC 0 1DC 1 1DC 2 1+KNC 0 1NC 1 1NC 2 1=
       Real Imaginary
                                                             Real Imaginar.
  ROOT NO. 5 -5.143
ROOT NO. 3 -5.143
ROOT NO. 1 -0.027
                                            ROOT NO. 4 -10.000
                            -5.468
                                                                      0.000
                             5.468
0.179
                                            ROOT NO. 2 -0.027
                                                                      -0.179
       0.200
K≖
    DC 0 JDC 1 JDC 2 J+KNC 0 JNC 1 JNC 2 J=
       2.753E 02 5.600E 03 4.415E 04 1.915E 05 9.827E 04 1.146E 04
                   Real Imaginary
                                                           Real Imaginary
  R00T HO. 5
R00T HO. 3
R00T HO. 1
                            -5.994
                                            ROOT NO. 4 -11.380
                 -4.196
                                                                       0.000
               -0.172
-0.397
                                            ROOT NO. 2 -4.196
                                                                       5.994
                             0.000
                             0.000
       0.500
    DE 0 JDE 1 JDE 2 J+KNE 0 JNE 1 JNE 2 J=
                                                          2.309E 05 2.104E 04
Real Imaginary
       2.753E 02 5.600E 03 4.415E 04 2.421E 05
                                                          Real
-12.777
                   Real Imaginary
 ROOT NO. 5
ROOT NO. 3
ROOT NO. 1
                                            ROOT NO. 4
ROOT NO. 2
                 -3.209
                            -6.779
                                                                      -0.000
                                                           -3.209
                -0.102
                            -0.000
                             0.000
                 -1.044
       0.300
    DE 0 3DE 1 3DE 2 3+KNE 0 3NE 1 3NE 2 3=
      2.753E 92 5.600E 93 4.415E 94 2.927E 95 3.634E 95 3.062E 94 Real Imaginary Real Imaginary
                   Real
                                           FOOT NO. 4 -13.804
  ROOT NO. 5
ROOT NO. 3
ROOT NO. 1
                 -2.512
                           -7.489
                                                                      -0.000
                           -0.000
                                            ROOT NO. 2 -2.512
                                                                       7.489
                -0.091
               -1.422
                           -0.000
```

```
DE 0 JDE 1 JDE 2 J+KNE 0 JNE 1 JNE 2 J=
      2.753E 02 5.600E 03 4.415E 04 3.264E 05 4.518E 05 3.701E 04 Real Imaginary Real Imaginary
                     Real
                              Imaginary
                                                                       Real
ROOT NO. 5
ROOT NO. 3
ROOT NO. 1
                 -2.144
                                                   ROOT NO. 4 -14.374
ROOT NO. 2 -2.144
                                                                                    0.000
                               -7.915
                                                                                    7,915
                                 0.000
                 -0.087
                  -1.592
                                 0.000
       2.000
   DC 0 JDC 1 JDC 2 J+KNC 0 JNC 1 JNC 2 J=
     2.753E 02 5.600E 03 4.415E 04 4.951E 05 8.937E 05 6.894E 04
Real Imaginary Real Imaginary
NG. 5 -0.869 -9.619 ROOT NO. 4 -16.508 0.000
NO. 3 -0.869 9.619 ROOT NO. 2 -0.081 0.000
ROOT NG. 5
POOT NO. 3
ROOT NO. 1
                                0.000
      3.000
   DC 0 3DC 1 3DC 2 3+KNC 0 3NC 1 3NC 2 3=
     2.753E 02 5.600E 03 4.415E 04 6.638E 05 1.336E 06 1.009E 05 Real Imaginary Real Imaginary
                 Real Inaginary
-0.022 -10.888
-0.079 0.000
                                                  ROOT NO. 4 -18.038
ROOT NO. 2 -0.022
ROOT NO. 5
                                                                                  -0.000
ROOT NO. 3
ROOT NO. 1
                                                                                  10.888
                                0.000
                  -2.181
      4.000
   DE 0 3DE 1 3DE 2 3+KNE 0 3NE 1 3NE 2 3=
      2.753E 02 5.600E 03 4.415E 04 8.324E 05 1.778E 06 1.328E 05
                                                                    Real Imaginary -19.265 -0.000
                     Real Imaginary
                                                  ROOT NO. 4
ROOT NO. 2
ROOT HO. 5
ROOT HO. 3
ROOT NO. 1
                              -11.917
                   0.635
                                                                    0.635
                                                                                  11.917
                  -0.078
                               0.000
                  -2.268
                                0.000
       5.000
   DE 0 JDE 1 JDE 2 J+KHE 0 JHE 1 JHE 2 J=
     2.753E 02 5.600E 03 4.415E 04 1.001E 06 2.220E 06 1.647E 05
Real Imaginary Real Imaginary
                     Real Imaginary
1.181 -12.795
ROOT NO. 5
ROOT NO. 3
                                                   ROOT NO. 4
ROOT NO. 2
                                                                    -20.304
                   1.181
                                                                                 -0.000
                                                                      1.181
                  -0.077
                                0.000
                                                                                  12.795
ROOT NO. 1
                  -2.322
                                0.000
      6.000
   DE 0 JDE 1 JDE 2 3+KNE 0 JNE 1 JNE 2 3=
     2.753E 02 5.600E 03 4.415E 04 1.170E 06 2.661E 06 1.967E 05
                                                                    Real Indeinary -21.214 -0.000
                     Reol Imaginary
                                                  ROOT NO. 4
ROOT NO. 2
ROOT NO. 5
                   1.654
                              -13.566
ROOT NO. 3
                  -0.076
                                0.000
                                                                     1.654
                                                                                13.566
ROOT NO. 1
                  -2.358
                                0.000
       7.000
  DE 0 1DE 1 1DE 2 1+KNE 0 1HE 1 1HE 2 1=
     2.753E 02 5.600E 03 4.415E 04 1.338E 06 3.103E 06 2.286E 05
Real Imaginary Real Imaginary
NO. 5 2.074 -14.257 ROOT NO. 4 -22.029 -0.000
                                                 ROOT NO. 4
ROOT NO. 2
ROOT NO. 5
                  -0.076
ROOT NO. 3
                                0.000
                                                                      2.074
                                                                               14.257
                  -2.384
ROOT NO. 1
                                0.000
  DEO IDE 1 IDE 2 1+KHE O IHE 1 IHE 2 3=
     2.753E 02 5.600E 03 4.415E 04 1.507E 06 3.545E 06 2.605E 05
Real Imaginary Real Imaginary
[ NO. 5 2.455 -14.888 ROOT NO. 4 -28.770 0.000
                                                  ROOT NO. 4 -
                 2.455
-0.076
ROOT NO. 5
                                                                                  0.000
ROOT NO. 3
ROOT NO. 1
                              0.000
                                                                      2.455
                                                                                 14.883
                 -2.404
                                0.000
```

1.000

K=

### K= 9.000 D[0]D[1]D[2]+KN[0]H[1]H[2]=

K= 10.000 DC0 DC1 DC21+KHC0 DC1 DC21=